

SUMMER 2013

CORNERSTONE

VOLUME 1 ISSUE 2

THE OFFICIAL JOURNAL OF THE WORLD COAL INDUSTRY

Fueling the Future with 21st Century Coal

Gregory Boyce



The Rio Summit: Waking Up to the Three Pillars of Global Poverty, Energy Access, and Coal

North American Shale Gas Production: A Bright Dawn for the Global Energy Trade or a Gloomy Monday?

Water Resource Protection Technology for Coal Mining in Western China



“ Our mission is to defend and grow markets for coal based on its contribution to a higher quality of life globally, and to demonstrate and gain acceptance that coal plays a fundamental role in achieving the least cost path to a sustainable low carbon and secure energy future ”

Milton Catelin
WCA Chief Executive

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The WCA provides a voice for coal in international environment and energy forums. This voice has been strengthened by WCA's recent growth in China, with the Shenhua Group, China National Coal Group and the China National Coal Association joining the WCA.

The Chairman of the Shenhua Group, Dr Zhang Xiwu, became Chair of the WCA in 2012 and will lead the work of the WCA over the next two years. This includes two exciting initiatives – the launch of the new WCA magazine “*Cornerstone – official journal of the world coal industry*” and the establishment of the World Coal Association Strategic Research Institute in Beijing.

It is an exciting time for the World Coal Association and for the global coal industry.

If you have an interest in the future of the coal industry, contact us to see how you can get involved: membership@worldcoal.org

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From the Ground Up



Holly Krutka
Executive Editor,
Cornerstone

The International Energy Agency as well as national/regional energy agencies have projected that coal will continue to be a key component of the energy mix well into the future. In fact, it is expected that coal will overtake oil as the most used form of primary energy as soon as 2017 (or even sooner by other estimates). Although the future use of coal may not be in question, that will give little relief to production companies that compete in a world with today's lower coal prices. The shale gas phenomena in North America, the recent global financial downturn, and, perhaps most importantly, the slowing of growth in China have dealt a major blow to many coal producers. In addition, with the confirmation of Ernest Moniz as the new Secretary of Energy, nomination of Gina McCarthy as the EPA Administrator in the U.S., and recent announcements from the Obama administration laying out a suite of climate change initiatives, CO₂ regulations for existing power plants are quickly becoming more likely. In the EU, considerable investment in energy infrastructure is needed, but where will it come from in the face of austerity measures and the uncertainty of the ETS? There are considerable challenges and many unknowns facing the coal industry at a time when world leaders struggle to find ways to reduce energy poverty and meet climate and sustainability goals simultaneously. Technology, such as using coal/biomass liquid fuels to reduce greenhouse gas emissions from the transportation sector, can play an important role, but government will be critical to moving technologies forward. Several articles in the second issue of *Cornerstone* look at these changes and challenges to the coal industry.

Facing and solving such challenges will be an effort tackled from the ground up; we must take a look at the global coal mining industry first. Solutions for coal producers will be fueled primarily through (1) educating/engaging with stakeholders and (2) technological innovation. However, the license to operate for the coal mining industry hinges on the widespread use of 21st century mining practices, including mine reclamation. When 21st century mining is employed, a permit for a coal mine is not a death sentence for the local ecology; in fact, modern coal mining can leave land in better shape than it was before mining, but such best practices must be encouraged. In some areas, water resources are scarce and can limit production, but a new technology has the potential to dramatically reduce water waste and pollution from mining. While technology can, and will, play a critical role in improving coal production, the employees will always be the most important asset to a coal producer. In Sub-Saharan Africa one company has found a way to fight the impact of the HIV/AIDS epidemic on its work force, taking care of both people and the bottom line. The people, policies, and technologies shaping the coal production industry are the focus of Issue 2.

On behalf of the editorial team, I hope you enjoy Issue 2 of *Cornerstone*. 🍷

FROM THE EDITOR

1 From the Ground Up

Holly Krutka

VOICES

11 China's Coal Industry Must Follow the Path of Sustainable Production Capacity

Xie Heping, Liu Hong, Wu Gang

16 The Critical Importance of Innovation for the Future of Coal

Robin Batterham

20 The Challenges of European Energy Infrastructure Finance

Nicholas Newman

24 Pollution Control of Coal-Fired Power Generation in China: An Exclusive Interview with Wang Zhixuan

Li Xing, Chen Junqi

POLICY & PEOPLE

29 The Rio Summit: Waking Up to the Three Pillars of Global Poverty, Energy Access, and Coal

Benjamin Sporton

33 What Will New U.S. DOE Leadership Mean for Energy?

Nancy Lamontagne

37 Profile of Gina McCarthy

Geoff Giordano

42 Healthy Business

Nikki Fisher



11



29



42

4 COVER STORY

Fueling the Future with 21st Century Coal

Gregory Boyce

The Chairman and CEO of Peabody Energy discusses the importance and challenges associated with meeting energy access needs today and in the future. With coal use slated to continue increasing, 21st Century Coal from modern mining to efficient, clean coal conversion will fuel the future.





45



61



75

STRATEGIC ANALYSIS

North American Shale Gas Production: A Bright Dawn for the Global Energy Trade or a Gloomy Monday?

Les Deman

45

Relationship between U.S. and International Coal Pricing

Emily Medine

50

Toward Market Launch of Coal/Biomass Coproduction Technologies with CCS

Robert Williams

54

ENVIRONMENT

Water Resource Protection Technology for Coal Mining in Western China

Gu Dazhao

61

Unblotting the Landscape

Lesley Sloss

66

Case Studies of Successfully Reclaimed Mining Sites

Holly Krutka, Li Jingfeng

70

GLOBAL NEWS

Covering global business changes, publications, and meetings

75



Official Publication of World Coal Industry



Sponsored by Shenhua Group Corporation Limited

WILEY

Published by John Wiley & Sons, Inc.

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Production and Layout
John Wiley & Sons, Inc.

CORNERSTONE (print ISSN 2327-1043, online ISSN 2327-1051) is published four times a year on behalf of the World Coal Association by Wiley Periodicals Inc., a Wiley Company 111 River Street, Hoboken, NJ 07030-5774.

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Fueling the Future



with 21st Century Coal

By Gregory H. Boyce

Chairman and Chief Executive Officer, Peabody Energy

For 16 years Thabo Molubi's productive day finished when the sun set. Without access to electricity, this South African furniture maker carved out a meager living with his hands. Then, an electrical line reached his village in the veld—and everything changed. He installed lights, power saws, and drills. He quadrupled productivity, improved product quality, and was able to hire local workers to sell his furniture far beyond his village.

Thabo Molubi joined the tens of millions of people who, every year, are leaving grinding poverty behind and entering the global middle class. When I came across Molubi's story in a piece by the American author Paul Driessen,¹ I was reminded of a conversation at the World Energy Congress. I had just concluded a speech calling on world leaders to prioritize an end to energy poverty. This is an environmental and energy crisis few acknowledge—yet it is far more immediate than the remote targets and timelines that consume the current conversation. After my remarks, a delegate from an African development bank approached. He noted that I was the first speaker to address an issue that was so central to his work. "Why," he asked, "do so many well-meaning officials claim to champion the developing world while denying access to the low-cost energy that could meaningfully improve the standard of living of impoverished people?"

Why indeed? An answer can be found in the widening fault line between the energy approaches of the developed and developing worlds. The world's rising economies recognize that energy is a human right and a growing need. Studies show that each tenfold increase in electricity is linked to a 10-year increase in life, and the United Nations^A has linked life expectancy, educational attainment, and income with per capita energy use.² In fact, access to affordable energy is instrumental to the achievement of the United Nations' Millennium Development Goals, which range from halving extreme poverty rates to achieving universal primary education by 2015.

The picture to the left exemplifies how Peabody Energy advances sustainable mining practices to restore coal-mined lands to prime and productive farmland here in central Indiana, as well as across the United States and Australia.

"Access to affordable energy is instrumental to the achievement of the United Nations' Millennium Development Goals, which range from halving extreme poverty rates to achieving universal primary education by 2015."

THE CHALLENGE DEFINED

Energy is as essential to our quality of life as food or water, and yet more than half the world's population, 3.6 billion people, lack proper energy access and 1.3 billion people have no electricity access at all.^{3,4} These men, women, and children finish their days early due to a lack of light. No refrigeration is available to keep food and medicines fresh. Doctors and nurses serve an estimated one billion patients in the dark. And approximately half of all primary school students in the developing world must study by candlelight.^B

It is flatly unacceptable that, in the 21st century, hundreds of millions of people still rely on traditional biomass for cooking and heat. In some nations, stoves burning wood, agricultural residues, and other wastes account for more than 90% of household energy consumption. Often women and children spend hours gathering these fuels—an activity that deforests landscapes, damages ecosystems, and wastes enormous human potential. The World Health Organization estimates that each year 1.3 million⁴ people die as the result of fumes from these indoor stoves.⁵

Without action, this gap can only grow. By mid-century, the global population is expected to reach nine billion people⁶; five out of every 10 could lack adequate access to energy based on predicted population growth. And while projected energy needs are staggering in the developing world, energy disparities are expanding even in the most developed nations. The International Energy Agency (IEA) called on nations to

invest US\$41 billion annually or risk failure in the global effort to eradicate energy poverty.⁷

This is a human tragedy, and an environmental crisis, that is entirely preventable.

A SOLUTION DELIVERED

As overwhelming demand looms, developing nations have embraced what, to some, is an unlikely solution: 21st Century Coal. The term “21st Century Coal” was introduced by the governments of China and the U.S. in 2009, in the context of an international partnership to advance the development of clean energy solutions from coal. It more broadly symbolizes the essential role of coal in achieving the world’s shared energy, economic, and environmental objectives. It also describes state-of-the-art advances across the industry in areas of safety, productivity, sustainability, and near-zero emissions technology in recent decades.

“Contrary to popular belief, most mining occurs above ground; 60% of global coal production, 67% of U.S. output, and 80% of Australian coal comes from surface operations.”

Few fully recognize the stark differences between negative stereotypes about coal mining and use and current reality. New technologies and coal mining techniques have made economic and environmental goals compatible and achievable. Consider the experience of the U.S., where technical investment transformed coal use into a great environmental success story. Tens of billions of dollars have been invested by U.S. utilities in clean coal technologies to reduce emissions over the past several decades. Since 1970, key emissions from coal-fueled generation have been reduced by 87% per megawatt hour⁸ during a time when coal electricity increased 115% and real U.S. gross domestic product more than tripled.

“Smokestacks” for coal plants have now become steam stacks, and a study in the *New England Journal of Medicine*⁹ revealed that air quality in major American cities is better than at any time in the last two decades, contributing to

measurable improvements in life expectancy—even as coal continues to provide more than 40% of U.S. power.

21ST CENTURY COAL ON THE PRAIRIE

21st Century Coal plants represent another leap forward, including one project not far from the headquarters of my company, Peabody Energy, in the U.S. Midwest. Equipped with \$1 billion in environmental controls, the Prairie State Energy Campus in southern Illinois is one of the cleanest coal-fueled power plants ever built and the largest to come on line in the U.S. in more than three decades. Prairie State, which was developed by Peabody, has achieved one-fifth the key emissions of conventional coal generating units while creating thousands of jobs.

Upgrading the world’s coal fleet with technologies like Prairie State would deliver a 90% improvement in sulfur dioxide, 93% less nitrogen oxide, and virtually zero particulates, while dramatically reducing the burning of fuel wood and waste that causes enormous indoor air pollution in developing nations. Today’s efficient plants also achieve a carbon dioxide emissions rate that is as much as 40% less than older plants being replaced (see Figure 1 for a comparison of CO₂ emissions versus net power plant efficiency).

Replacing the world’s older coal plants with advanced generation would be the carbon emissions equivalent of removing the entire U.S. passenger car fleet from the roads. Doing so also would drive \$4.3 trillion in economic gains and 21 million new construction jobs, according to a study by Management Information Services.¹⁰

The fact that this can be accomplished today with commercial technologies is not lost on the leaders of the world’s best economies.

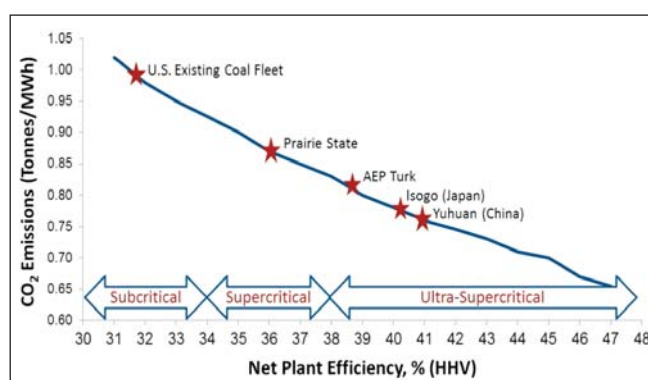


FIGURE 1. CO₂ Emissions Decline as Net Power Plant Efficiency Increases



FIGURE 2. Coal Demand Growth 2010–2035 (millions of tonnes, U.S. shown in short tons)^{6,7}

Nations such as China face what is often called a “prosperity paradox.” In a single generation, China has lifted hundreds of millions of people out of poverty—an accomplishment unparalleled in human history. Chinese use of low-cost coal has powered this prosperity, with coal use increasing 260% since 1990 as China’s Gross Domestic Product rose 20-fold in nominal terms. The correlation prompted the IEA to call China a “coal-fueled economic miracle.”¹¹ And yet, China also faces intense pressures due to the pace of its urbanization and industrialization that threaten to undermine its achievement. Some 200 million Chinese moved to megacities in the past decade in the largest human migration ever recorded, and the China Institute for Reform and Development estimates that this number could double by 2020. Within the next 10 years, more people could urbanize in China than live in the entire U.S.

This prosperity paradox is echoed in developing nations around the world. Every day, more than 367,000 people are born.¹² Hundreds of millions more Thabo Molubis will soon be looking for a better life through modern power, and energy use is expected to intensify as a direct result. Many are asking how we can meet such enormous need without straining scant resources and degrading environmental quality.

Once again, China is leading the way to the answer. This Asian nation recognizes that advancing energy access through greater

use of coal need not come at the expense of environmental progress. Economic strength has been linked with clean air and water in much of the world. Evidence and common sense tell us that more prosperous nations can afford greater environmental protections and more advanced technologies. This is why China is prioritizing economic and technological development as the most effective path to cleaner air. Chinese leaders are building more supercritical and ultra-supercritical coal plants than any other nation in the world. This one nation represents a remarkable 55% of the global advanced coal-fueled generation that is expected to come online by 2017 (see Figure 2 for the projected coal demand growth through 2035).¹³ As part of the country’s 12th five-year plan—its national blueprint for economic and social development—China has committed to decommissioning the nation’s oldest plants and deploying modern emissions control technologies in the existing fleet. These advances cannot arrive soon enough. China’s per capita electricity use today is equal to the U.S. in 1955; India’s per capita electricity use is equal to the U.S. in 1920. We are just at the beginning of this story.

A FUTURE FOR NEAR-ZERO EMISSIONS

We also are just beginning to realize the potential of the next phase of 21st Century Coal technologies involving carbon dioxide capture, use, and storage (CCUS). While many

proposed climate change policies continue to divide the global public, the science behind coal with carbon management is solid and widely understood. Studies indicate coal with CCUS is cost competitive with nuclear and natural gas with CCUS. These “green coal” technologies achieve near-zero greenhouse gas emissions by capturing and injecting carbon dioxide into aging oil fields to recover stranded oil or sending it deep into saline aquifers or other geological formations for safe storage.

Perhaps the best example of green coal is a plant just outside Tianjin, China. GreenGen is a major coal gasification plant that will ultimately reuse carbon dioxide for enhanced oil recovery. It is one of the world’s largest near-zero emissions projects, it began generating commercial power in 2012, and Peabody is the only non-Chinese partner in the project.

THE MODERN COAL MINE

A visit to Prairie State or GreenGen dispels many myths about coal-fueled electricity generation today. Similarly, I find that visitors to Peabody’s mining operations from outside the industry are amazed by the scale and sophistication of modern coal mining. Contrary to popular belief, most mining occurs above ground; 60% of global coal production, 67% of U.S. output, and 80% of Australian coal comes from surface operations. The best operations are characterized by large size, world-class safety and health management systems, highly skilled workforces, and state-of-the-art machinery.

21st Century Coal mining operations demand an intense focus on the fundamentals of operational excellence. Everything matters—from environmental standards to workforce training. But no issue is of greater importance than safety. For example, Peabody recently delivered the safest year in company history in 2012 by making safety a way of life, a method of working and living. Our focus on delivering zero incidents of any kind is relentless and resulted in a global incidence rate of 1.82 last year, a 9% improvement from 2011 and the fifth consecutive year of record safety performance. Peabody is not alone: In the U.S., working at a mine is safer than working in a shopping mall, in construction, or many other fields according to incidence rate data from the U.S. Occupational Safety and Health Administration and the U.S. Mine Safety and Health Administration.

Having made a career in mining, I have a deep respect for those who choose this industry as a career, and I also recognize the scope of our collective responsibility to ensure that effective health and safety standards are in place and followed. For this reason, during my Chairmanship of the



Peabody Energy’s Coppabella Mine in Australia Serves Export Markets in Asia and Produces Low-Volatile Pulverized Coal Injection Coal to Make Steel

National Mining Association (NMA), we established a CEO Safety Task Force which set an industry goal of eliminating fatalities and reducing reportable injuries by 50% within five years. To accomplish this objective, representatives of NMA member companies collaborated on development of a model safety and health management system called CORESafety, which is based on the best practices of other industries. The CORESafety system is designed to be adaptable to all mining companies, is complementary to existing safety and health initiatives, and is currently being implemented across the U.S. mining industry.

Peabody has sought to share best practices and forge global partnerships that can result in improved safety performance, resource recovery rates, land restoration, water resource management, and environmental monitoring. When mining is complete, lands are returned to a condition that is the same, and often far better, than before mining occurred. For example, in 2012 Peabody Energy alone restored more than 4000 acres of wetlands, prime farmland, forests, and prairie across two continents and recycled more than 18,000 tons of materials.

“Everything matters—from environmental standards to workforce training. But no issue is of greater importance than safety.”

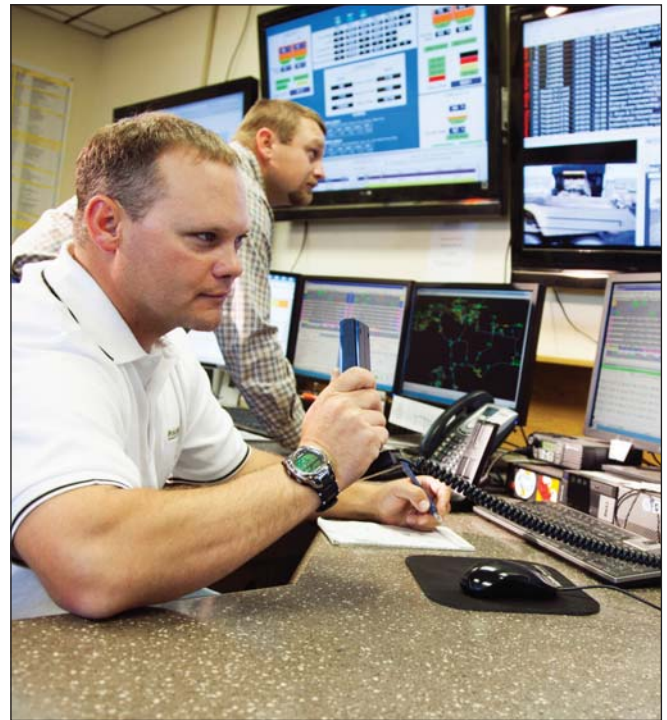
China is making significant progress in this area, as well, and has responded to recent safety and environmental challenges by shuttering small, less-regulated mines and emphasizing win-win international partnerships that promise to introduce advanced, large-scale surface mining techniques in its far western regions.

ADVANCED TECHNOLOGY DRIVES MODERN MINES

Advanced technology is the backbone of this effort. Peabody employs global positioning satellites, real-time monitoring systems, and computerized dispatching technologies to improve operating efficiency. Thermographic cameras help technicians measure heat differentials in equipment and conserve energy and improve equipment availability; acoustic listening devices assist employees in performing preventative maintenance; and proximity detection systems prevent collisions in high-congestion, low-visibility areas. An example of advanced technology is modular mining technology that synchronizes haul truck routing to optimize coal blends for customer requirements.

21st Century Coal mining also features machines of significant size and complexity, including haul trucks capable of carrying more than 400 tons, massive shovels and draglines, and underground longwall mining systems with more parts than an average supercomputer. Peabody commissioned a haul truck capable of holding 447 tons, enough to qualify for the *Guinness Book of World Records*, and we developed a conveyor and blending system at our North Antelope Rochelle Mine (NARM) in Wyoming that enables this single operation to transport and blend coal over great distances with precision.

The pace of innovation is intense, but the potential for improving lives and livelihoods is immense. The world has nearly a trillion tons of proven coal, which makes up 60% of global energy resources. Coal is widely dispersed and broadly available,



Peabody Energy Operators Monitor Real-Time Computerized Dispatching Technologies that Monitor Productivity and Improve Operating Efficiencies

with coal mines in 70 nations (the top 10 coal producers are listed in Table 1). Coal also is easily transported, reliable, and affordable.¹² It remains the leading baseload fuel to replace declining nuclear generation and maintains a distinct cost advantage over liquefied natural gas globally.

FUELING THE FUTURE

Looking ahead, it is time to find some common ground on coal. For too long, energy policies in many nations have defaulted into predictable positions: business against activists, coal versus gas versus renewables, nation versus nation. The world often seems entrenched in a debate based on fixed opinions and fuzzy data. It is time to recognize the realities of 21st Century Coal mining

TABLE 1. List of Top 10 Global Coal Producing Countries

Top Ten Coal Producers (non-lignite) in 2011			
China	3471 Mt	Russia	334 Mt
U.S.	1004 Mt	South Africa	253 Mt
India	585 Mt	Germany	189 Mt
Australia	414 Mt	Poland	139 Mt
Indonesia	376 Mt	Kazakhstan	117 Mt

and use. It is also time to empower people like Thabo Molubi to achieve better health and wealth through the greater use of affordable energy, which largely comes from coal.

Common sense tells us that the world cannot regulate, tax, or conserve its way out of our current global economic stagnation. The solution is a balanced policy framework that encourages and rewards greater use of coal in a low-carbon way. 21st Century Coal can combat energy poverty and fuel an industrial rebirth. We believe it will take five steps, what we call the Peabody Plan:

- First: We must work to eliminate energy poverty by ensuring that at least half of new generation is fueled by coal;
- Second: Replace older traditional coal plants with advanced coal technologies;
- Third: Develop at least 100 major carbon capture, utilization, and storage projects around the world within 10 years;
- Fourth: Deploy significant coal-to-gas, coal-to-chemicals, and coal-to-liquids projects globally in the next decade; and
- Finally: Commercialize next-generation clean coal technologies to achieve near-zero emissions.

It is time to finally approach energy issues pragmatically—and recognize that the answers are right under our feet. It is time to act on available technology solutions. It is time to rebuild our nuclear power infrastructure, explore for natural gas and oil, and develop more cost-efficient renewables. Most of all, it is time to drive an energy technology renaissance with 21st Century Coal. 🌱

NOTES

- A. Analysis by Dr. Frank Clemente, Pennsylvania State University, based on International Energy Agency World Energy Outlook, 2012, and The World Bank World Development Indicators, 2012.
- B. Analysis of United Nations Population Division, “The World at Six Billion,” Dr. Frank Clemente, Pennsylvania State University; International Energy Agency, World Energy Outlook, 2012; World Coal Institute, “Coal Tackling Poverty,” 2007. World Health Organization, 2012 data.

- C. Ultimately recoverable demonstrated reserves on Btu basis. United States Geology Service, National Assessment of United States Oil and Gas Resources, U.S. Coal Reserves; World Energy Outlook 2012, International Energy Agency; Annual Energy Outlook 2012, Energy Information Administration; Peabody analysis.

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13. Platts, World Electric Power Plant Database, January 2013, and Peabody Energy global analytics.

China's Coal Industry Must Follow the Path of Sustainable Production Capacity

By Xie Heping

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In the last 10 years, affected by strong market demand, China's coal output has continued to increase and its production capacity has expanded at an unprecedented rate, with an annual increase in production of 200 million tonnes on average. In 2012, the total output of coal reached 3.66 billion tonnes. However, based on China's existing coal mining technologies, this level of output greatly exceeds the sustainable coal production capacity in terms of resources, the environment, and safety. Behind this huge production statistic are excessive waste of coal resources, a large number of casualties among workers, and serious damage to water resources and the environment. These problems are the basis of resistance for the continued development of China's coal industry.



A Longwall Mining System Can Be Employed During Highly Mechanized Mining

According to our latest research, which comprehensively examines the various constraints of resources, technology, environment, safety, etc., sustainable capacity for China's coal mining is only around 1.1 billion tonnes, approximately one-third of current total coal production. In other words, due to limited resources, poor geological mining conditions, natural disasters, environment-based restrictions, and water limitations, only one-third the rate of current coal production in China can be considered rational; the other two-thirds exceeds sustainable capacity and can be considered over-exploitation.

"According to our latest research... sustainable capacity for China's coal mining is only around 1.1 billion tonnes, approximately one-third of current total coal production."

CHINA'S MAXIMUM SUSTAINABLE COAL PRODUCTION CAPACITY UNDER CONSTRAINTS

Although China is rich in coal resources, based on the current massive production rates, every step to enhance the production capacity will be subject to constraints from many unfavorable factors. First, coal production capacity is constrained by resource reserve conditions. Coal resources buried at a depth of 1000 m account for 53% of China's total reserves. After long-term large-scale exploration, shallow coal resources in the key coal production areas have been depleted, leaving an average mining depth of approximately 600 m. Coal exploration becomes more difficult as the mining depth increases, plus there is also a lag in technology. Therefore, the problems associated with deep mining will increase.

Second, coal production is constrained by safety. Some coal fields in China are more difficult to mine because of their

complicated geological structure and high gas content, which leads to frequent mining accidents. The annual death toll in China's coal production accidents has exceeded 2000, which is the highest in the world in terms of mortality rate per million tonnes. Especially in northern China, the coal fields have inherent safety risks due to the serious threat from the Ordovician limestone water at the bottom of the coal bed.

Third, coal production is constrained by the environmental impacts of mining (i.e., environmental capacity). The hydro-geological conditions and ecology in most of China's coal-rich regions are fragile because of severe soil erosion, frequent geological disasters (i.e., mudslides, landslides), and low vegetation cover. With further mining exploration, the environment near the mines will be subject to more serious damage, which could result in a considerable threat to the social development and quality of life for the residents in mining regions.

We have conducted a regional analysis to calculate the sustainable production capacity limit under the major constraints of the environment, water resources, geological mining conditions, and safety.

In terms of environmental constraints, due to the fragile ecology of Shanxi, Shaanxi, Inner Mongolia, and Ningxia, the coal production capacity in these regions should be limited to 2.1 to 2.2 billion tonnes. In southwest China, where the use of high-sulfur coal is restricted, the production of middle and low-sulfur coal is approximately 300 million tonnes. Considering the overall situation, the annual mining capacity under the environmental constraints in China should be 4.2 billion tonnes (i.e., equivalent to 3.0 billion tonnes of standard coal).

Coal exploitation is extensive in Shanxi, Shaanxi, Inner Mongolia, and Ningxia. However, due to water shortages in these areas, production capacity should be limited to 2.4 billion tonnes. Water resources have little impact on the sustainable production capacity in other regions, which amounts to 1.9 billion tonnes. Therefore, taking into consideration the constraints from water resources in China, the annual sustainable mining capacity is 4.3 billion tonnes (equivalent to 3.1 billion tonnes of standard coal).

With respect to the occurrence of resource reserves and constraints related to mining conditions, a considerable portion of coal resources are inappropriate for large-scale mechanized production. The mining capacity suitable for mechanized exploitation is approximately 4.7 billion tonnes (equivalent to 3.4 billion tonnes of standard coal); 3.5 to 3.8 billion tonnes (equivalent to 2.5–2.7 billion tonnes of standard coal) of annual capacity are available for high-efficiency mechanized exploitation.

In term of safety, which is determined by geological mining conditions, water resources, and technology, the annual mining capacity in China should be 3.5 billion tonnes (equivalent to 2.5–2.7 billion tonnes of standard coal). Safety during coal mining poses the largest constraint to coal production expansion.

Based on the above analysis, we propose that China's maximum annual coal production capacity should be limited to 3.8 billion tonnes (equivalent to 2.7 billion tonnes of standard coal) to maintain the healthy and sustainable development of China's coal industry. See Table 1 for the detailed data on sustainable production capacity based on the various constraints.

TABLE 1. Maximum Production Capacity of China's Coal Resources under Constraints (Units: million tonnes)

	Mechanized Mining	Safe Mining	Environment	Water	Comprehensive Analysis
Nationwide	4710	3520	4190	4320	3820
East China	500	260	760	760	760
Northeast China	120	80	160	160	160
South China	20	20	110	110	100
Shanxi, Shaanxi, Inner Mongolia, Ningxia	3200	2620	2000	2400	2000
Southwest China	360	60	300	390	300
Xinjiang - Qinghai Area	510	480	760	500	500

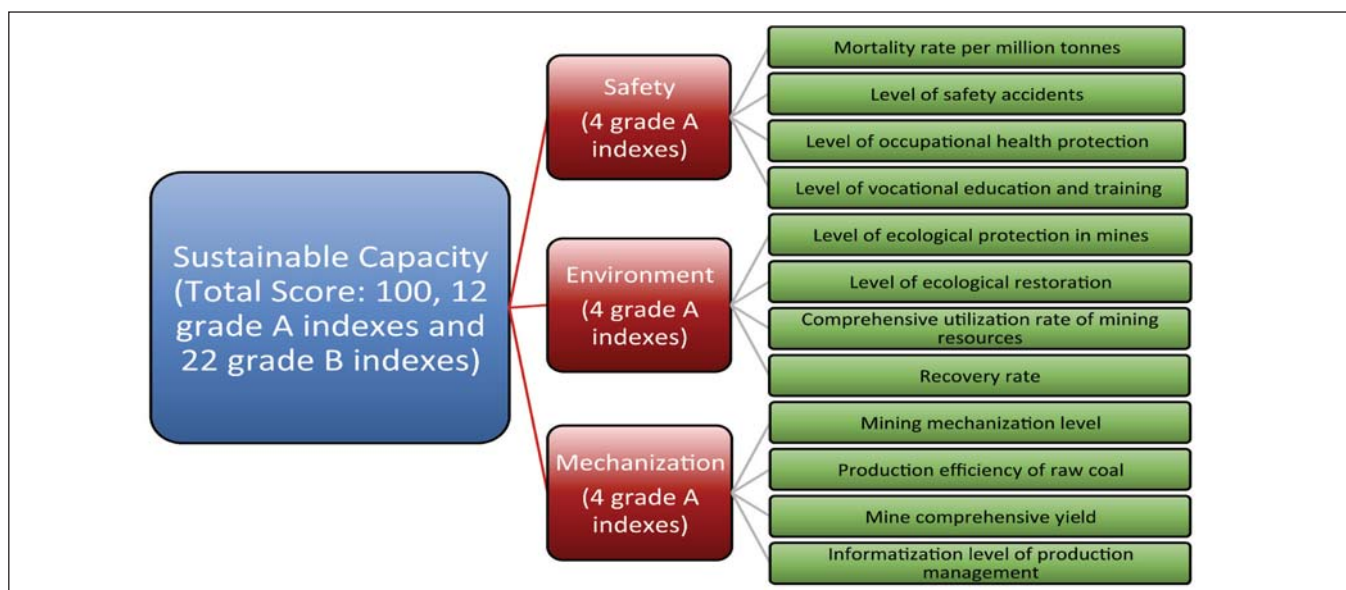


FIGURE 1. Assessment Index of the Sustainable Coal Production Capacity

A STANDARD SYSTEM TO DEFINE SUSTAINABLE COAL MINING CAPACITY IN CHINA

Our definition of sustainable coal mining capacity refers to the maximum coal mining capacity that can be achieved using safe, highly efficient, and environmentally friendly methods under the premise that the coal reserves can be sustainably mined for a specific time period. Based on the requirements to sustain production capacity under the constraints determined based on resources, safety, technology, the environment, and equipment, we set up an assessment index system to evaluate sustainable production capacity. Three indexes are proposed to define sustainable mining capacity: safety, environment (i.e., green), and mechanization. This assessment system consisted of preparing a hierarchy of metrics, referred to as grade-A and grade-B indexes, wherein the grade-A indexes are primary indexes and the grade-B are secondary indexes. Figure 1 lists the 12 grade-A indexes; there are also 22 grade-B indexes that are not shown.

Safety

The safety level refers to the degree of safety and health protection for coal miners in the process of production and operation, placing an emphasis on a low accident rate, low incidence of occupational diseases, and guaranteed occupational safety and health in accordance with the “people-oriented” development concept. This index contains four grade-A indexes and seven grade-B indexes.

Environment

The environmental (i.e., green) level refers to the degree of protection provided to the environment in and around the mining areas during coal production. The environment level is based on complying with environmental regulations and addressing the environmental problems caused by traditional mining processes. It requires achieving the environmental benefits associated with a high recovery rate of coal resources, while minimizing the overall impact to the environment. In addition, the environmental level is characterized by the simultaneous extraction of other resources without negative environmental impacts. This index contains four grade-A indexes and eight grade-B indexes.

Mechanization

The mechanization level refers to the degree of utilization of the most efficient mining mechanization appropriate for the specific geological conditions. The mining mechanization level emphasizes efficient mining and the overall production efficiency rate, widespread use of technology and improvement through analytical assessment, and better equipment adaptability. This index consists of four grade-A and seven grade-B indexes.

Using our assessment system, we completed a comparative study on the sustainable capacities of coal mining, ranking the world’s major coal mining countries. The results are provided in Table 2.

SCALE AND REGIONAL DISTRIBUTION OF SUSTAINABLE COAL MINING CAPACITY IN CHINA

According to the assessment system, we estimated the sustainable coal mining capacity in China, including a breakdown of the major coal production areas, and came to the conclusion that the current sustainable production capacity in China is approximately 1.1 billion tonnes, that is, approximately one-third of the current national annual output.

In addition, we developed a preliminary forecast for potential improvement of China's sustainable coal mining capacity in the future. By 2030 it is projected that the sustainable coal mining capacity in China's existing mines could increase to 1.50–1.63 billion tonnes. Sustainable coal mining capacity in new mines may reach 1.58–1.89 billion tonnes by a conservative estimate, or up

to 1.90–2.11 billion tonnes based on an optimistic estimate. The total sustainable capacity of coal mining in 2030 is estimated to be 3.0–3.5 billion tonnes, which can basically meet the projected coal demand in China at that time. After 2030, China's annual coal demand is not expected to increase or change dramatically, so the total sustainable coal production capacity will be maintained at approximately 3.0–3.5 billion tonnes.

According to our analysis of major coal mining regions within China, the sustainable mining capacity in Shanxi, Shaanxi, Inner Mongolia, Ningxia, and Gansu is approximately 648 million tonnes, accounting for ~60% of the national sustainable capacity. It is estimated that by 2030, the sustainable mining capacity in this region could increase by 1.06–1.13 billion tonnes. The sustainable capacity of coal mining in east China is approximately 330 million tonnes, or ~31% of national

TABLE 2. Comparison of Sustainable Coal Mining Capacity between China and the Advanced Coal Mining Countries in the World

	U.S.	Australia	UK	Germany	China
Mining Safety Level (34 points)	34	34	34	34	11
Mining Green Level (30 points)	24	27	27	27	12
Mining Mechanization Level (36 points)	36	36	32	32	20
Scores for Sustainable Coal Mining Capacity (100 points)	94	97	93	93	43

TABLE 3. The Sustainable Coal Mining Capacity in 2010 in China by Coal Production Region

Coal Production Areas	Shanxi, Shaanxi, Inner Mongolia, Ningxia, and Gansu	East China	Northeast	South China	Xinjiang— Qinghai Area	Whole Country
Coal Output (millions of tonnes)	1850	640	190	460	100	3240
Sustainable Capacity (millions of tonnes)	648	330	55	20	25	1078
Proportion of Local Sustainable Capacity in National Sustainable Capacity	60.11%	30.61%	5.10%	1.86%	2.32%	100.00%
Proportion of Sustainable Capacity in Regional Coal Output	35.03%	51.56%	28.95%	4.35%	25.00%	33.27%

sustainable capacity. By 2030, the sustainable mining capacity in this region could increase by 300–350 million tonnes. The sustainable mining capacity in northeast China is about 55 million tonnes, or 5.1% of the national sustainable capacity. The predicated sustainable mining capacity in this region could increase by 90–100 million tonnes by 2030. Sustainable mining capacity in south China is approximately 20 million tonnes, or 1.86% of the national sustainable capacity. This can be expected to increase by 30–50 million tonnes by 2030. Sustainable mining capacity in the Xinjiang-Qinghai area is about 25 million tonnes, or 2.32% of the national sustainable capacity and 25% of local coal output. Such capacity in this region could increase by 20–30 million tonnes by 2030. See Table 3 for the sustainable capacity and regional distribution of coal mining in China.

DEVELOPMENT PATH TOWARD SUSTAINABLE COAL MINING CAPACITY

In order to facilitate China’s progress toward achieving a sustainable coal mining capacity and to thoroughly improve mining-related issues and prevent over-exploitation, it is necessary to establish an improved policy and standards system and set the mandatory market threshold (i.e., production limit) based on the sustainable capacity. To increase the sustainable capacity of coal mining in China, we propose taking measures such as integration of the country’s coal resources as well as merger and reorganization of coal mining enterprises to accelerate the development of large-scale modern groups that will possess advanced technical

capabilities, and especially make progress on construction and demonstration of the nationally planned 14 large-scale coal production bases with the mindset of achieving sustainable capacity development.

The development of a sustainable coal mining capacity in China can be implemented in “three steps”. First, from 2010 to 2020, there will be a mandate to “maintain the existing sustainable capacity coal mines, upgrade some coal mines to a sustainable capacity level, and focus on new coal mines that follow a sustainable capacity standard”. Specifically, this means that it is important to (1) maintain the mining capacity of the existing one-third of mining operations that have already reached the standard of sustainable capacity, (2) improve another one-third that have yet to meet the standard, but can be upgraded by means of technological development and innovation, and (3) gradually eliminate the remaining one-third of mining operations that will not be able to meet the standard. We propose that it is possible, and necessary, for China’s coal industry to make the adjustments listed above to be on the path toward achieving a sustainable coal mining capacity before the year 2020. As the second step, from 2020 to 2030, we propose achieving the goal of a sustainable coal mining capacity throughout China. And finally, from 2030 to 2050, we believe that China’s coal industry could establish a sustainable coal production industry and become a world leader in the field of coal exploration. 🌱

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Coal Exporters

Coal reserves are available in almost every country worldwide, with recoverable reserves in nearly 80 countries. Although the biggest reserves are in the U.S., Russia, China, and India, coal is actively mined in more than 70 countries. By contrast, Russia, Iran, and Qatar control 53.2% of the world’s gas reserves, and over 50% of the world’s oil reserves are located in the Middle East. Most coal is consumed domestically; only 15% is traded internationally. In a number of countries coal is also the only domestically available energy fuel, and its use is motivated by both economic and energy security considerations. This is the case in countries and regions such as Europe, China, and India, where coal reserves are much higher than oil or gas reserves. Most of the world’s coal exports originate from countries considered to be politically stable, a characteristic that reduces the risks of supply interruptions. A list of the top coal exporters is shown in the table at the right.

	Total (Mt)	Steam (Mt)	Coking (Mt)
Indonesia	309	309	0
Australia	284	144	140
Russia	124	110	14
U.S.	97	34	63
Colombia	75	75	0
South Africa	72	72	0
Kazakhstan	34	33	1

Source (text): WCA Coal Matters Factsheet (www.worldcoal.org)

Source (table): IEA Coal Information 2011 (wds.iea.org)

The Critical Importance of Innovation for the Future of Coal

By Robin Batterham

Kernot Professor of Engineering,
The University of Melbourne

WHAT COULD DIMINISH THE DOMINANCE OF COAL?

“Coal use has never stopped increasing and the forecasts indicate that, unless a dramatic policy action occurs, this trend will continue in the future. If this happens, then the IEA believes greater efforts are needed by governments and industry to embrace cleaner and more efficient technologies to ensure that coal becomes a much cleaner source of energy in the decades to come.”¹

This International Energy Agency (IEA) quote tends to say it all, namely, that the dominance of coal is here for some time to come, at least in non-OECD countries. It also raises the legitimate question as to what, if anything, could change the role coal plays in power generation, currently at 41% worldwide.² There are strong views supporting the ongoing dominance of coal, e.g., from the former Chairman of the World



This Coal Sorter Is an Example of the Type of Cutting Edge Innovation that Will Be Necessary for the Coal Industry to Maintain Competitiveness

Coal Association³, but equally a balancing voice from the Chief Economist of the IEA in the first issue of *Cornerstone* to suggest that, ultimately, “Government decisions...are crucial to the future demand for coal.” Government is a key part of the “license to operate.”⁴

I suggest there are two key drivers that must be satisfied if coal is to remain dominant for decades:

- Relentless innovation to stay competitive
- Maintain the public license to operate

The points above will be explored in two separate articles; this is the first installment, focused on innovation, of the two-part series. The public license to operate is not just about the legitimacy of coal in general (i.e., mining, sustainability, emission profile, safety profile), but also covers technology, particularly new technologies.

“Innovation is taken seriously in the coal industry, but I would suggest that a lot more could and should be done.”

RELENTLESS INNOVATION TO STAY COMPETITIVE

Step-change innovations are relatively rare in any mining or process industry. They do occur, of course, but are limited by development times and high capital costs, which diminish the appetite for risk and the time necessary to move from laboratory scale to full scale. Significant examples for coal-related step-change innovation have been the introduction of open pit mining and longwall mining. Smaller incremental changes via continuous improvement are far more common, e.g., improved flotation cells for coal cleaning, optimization of drag lines, on-belt measurement of ash and moisture. The list is long and helps to explain why, averaged over a few years, *commodity prices can fall in real terms forever*. Figure 1 is a composite of many commodities, including coal, and shows a steady fall in real prices over a 200-year period. This is

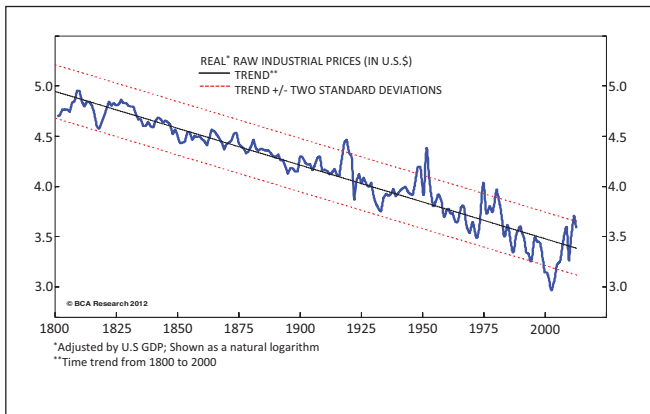


FIGURE 1. Over a Long Time Period Commodity Prices Fall in Real Terms⁵

extraordinary in that, while demand for the commodities in this index has been increasing, on the supply side we have seen costs heading in the opposite direction.

Although the price of coal spiked in recent years⁶, along with other commodities it has now fallen well back. This reminds us that when coal loses its cost competitiveness, substitutes can move in quite rapidly.

Overall, there can be only one answer as to why prices fall in real terms when demand is rising and extraction is becoming more difficult: Innovation is occurring. It is all too easy to overlook the relentless march of innovation. The Club of Rome in 1972 got it right when they suggested that the future of the world would be very dependent on energy.⁷ They got it wrong, however, in predicting the end of oil in 1992 and gas in 1994. We still have to wait on their 2083 coal prediction. What has happened, of course, is that as demand has risen and easy-to-win resources have been depleted, we have simply moved down the resource pyramid to lower rank or more difficult-to-win materials and relied on innovation to lower costs in real terms.

This race, now documented for over 200 years, is driven by innovation, but has two intertwined goals. The first target of innovation is individual competitive advantage against other companies. This is relentless and inevitably drives companies toward lowering costs. A company that fails to innovate loses its margins as its competitors reduce their costs through innovation.

Second, as any particular innovation spreads through the industry (and spread it will, it is only a matter of time), the net effect is to keep coal competitive against other sources of energy. That said, other energy producers also have their own

innovation race: We only have to look at the reduction in price of photovoltaics over the last 20 years to acknowledge that no one escapes the innovation race—no individual company and no particular industry. *Without innovation, coal dies.*

WINNING THE INNOVATION RACE

Understanding how innovation happens is well documented⁸; the real question is when the benefits are so clear, why is the risk appetite for innovation so low? In Australia, surveys indicate that less than 40% of firms innovate.⁹ One of the prime reasons is that the time required to bring new technologies into everyday use in the coal industry is long. Capital-intensive industries involve long time scales for new technologies, as experience from BHP-Billiton indicates¹⁰ (see Figure 2). Whether a major innovation such as CCUS (carbon capture, utilization, and storage) or a somewhat smaller one such as Jameson flotation cells, the time scales are in years, not months.

There are many other reasons why firms choose not to innovate but, to look on the positive side, my own experience in the process industries suggests that risks are minimized when large-scale implementation is supported by ongoing R&D. This is counterintuitive to many who see that R&D stops once large-scale implementation starts. One could cite many examples, including cases where billions of dollars have been lost through missing this point. For this underlying, but critical, R&D, companies have many options, including direct support and proven channels for collaboration.^A The industry levy model has worked well over many years.^B

Thermal Efficiency: The Elephant in the Room

China's success related to energy efficiency gains is a lesson to the world in coal utilization. Emissions per capita decreased

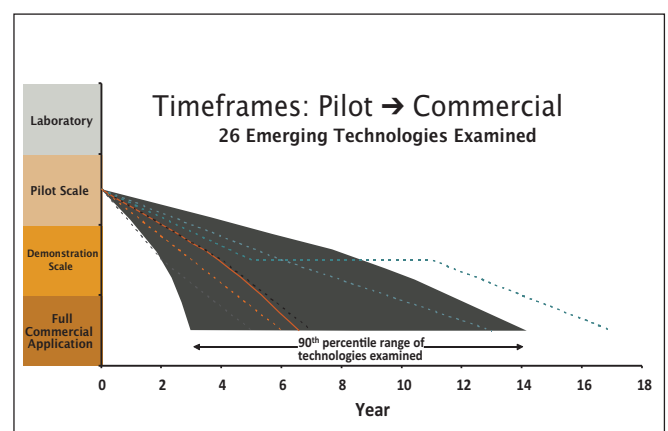


FIGURE 2. BHP-B Experience of Implementation Time for New Technologies

by 15% between 2005 and 2011.¹¹ This is an extraordinary result and stems from a focused approach of installing new capacity at the leading edge of thermal efficiency. It is well established that a 1% improvement in thermal efficiency results in a 2–3% reduction in emissions.¹² Thermal efficiency is “the elephant in the room” in terms of potential to reduce emissions. As pointed out by the IEA, the world average on thermal efficiency is only 30%.¹³ Movement to the European average would see global efficiency at 38%, to state-of-the-art technology would see efficiency at 45%, and even 50% could be possible.¹⁴ If coal-fired power plants worldwide operated at 700°C, a 40% reduction in emissions would result. Throw in CCUS on top of this and the reductions would be 90% compared to present levels.

At this point, it should be acknowledged that major innovation in coal use, e.g., in power stations, involves even higher capital intensities than in coal production. As such, incentives such as a price on carbon emissions will have to be quite high to induce change in existing plants. Present levels in OECD countries are inadequate.

Process Opportunities

Many possibilities exist in the upstream part of coal production where significant improvements can be made. Targeting grade improvement in processing is powerful in that it allows more recovery in mining and not just lower costs in processing.

Advances in grade improvement are coming fast in key areas, for example:

- Sorting^c, where tonnages to 400 tonnes/h are possible and where dual energy X-ray transmission easily sorts coal from wastes or marginal torbanite
- Flotation¹⁵, where new equipment is showing possibilities of coarse particle flotation to millimeter size and fine particle flotation to micron size
- Micronizing¹⁶, where flotation can be used to separate ash components and give a product of very low ash, suitable for direct injection into engines¹⁷

Ultra-fine coal dewatering and low-rank coal dewatering have been on the agenda for over 100 years. The U.S. Department of Energy has funded significant work in recent years in the use of dewatering aids, hyperbaric centrifugal filters, and the dewatering by displacement process.¹⁸ Upgrading of low-rank coals has long been possible technically; to date the challenge has been related to the economics and the engineering detail. As well, many of the products from these processes have suffered from self-heating or dusting problems. One (of many)

that looks particularly promising is the mild hydrothermal upgrading recently demonstrated by the Exergen company with results at tonnage scales. A range of low-rank coals have been upgraded from moisture contents around 60–70% to product at 20–25%.¹⁹ Hydrothermal dewatered coal slurry appears to be an ideal fuel for high-efficiency direct injection coal engines.

Perhaps the most fruitful area for the mining side of the coal industry is to move even further into automation. This is happening worldwide at an increasing pace with remote control centers now being commonplace and thousands of kilometers distant. Thus far, the mineral industry leads the world with autonomous drills, trucks, and trains in use. One company alone will have 150 autonomous trucks operating in the Pilbara (Western Australia) region within the next three years, hauling 20 million tonnes/d.²⁰ The coal industry has done well in particular areas (e.g., drag line automation), but has yet to fully embrace and benefit from the advances now seen in the mining of minerals.

Is the Coal Industry Winning the Innovation Race?

Overall, there are encouraging signs that innovation is taken seriously in the coal industry, but I would suggest that much more could and should be done, particularly in targeting efficiency improvements from the resource in the ground through to final products such as power in the grid. Regarding the necessary innovation in these areas, there is still a long way to go. 🤖

NOTES

- For example, see AMIRA at www.amira.com.au
- For example, see ACARP at www.acarp.com.au
- For examples, see www.ultrasort.com.au/info2/photoFlyer.pdf and www.tomrasorting.com

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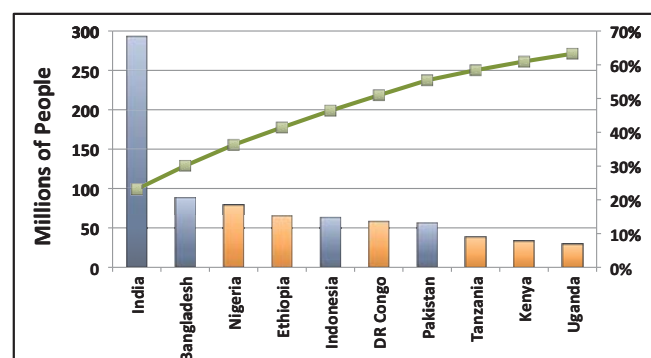
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What Would It Take to Provide Energy Access to All?

Currently, approximately 1.3 billion people in the world lack access to electricity and 2.6 billion are without access to clean cooking sources—even after these numbers declined by 50 million and 40 million, respectively, in 2011. The IEA's World Energy Outlook 2012 examined what would be required to provide energy access for every person in the world and developed what IEA refers to as an “Energy for All Case”. The investment necessary to achieve the goal of energy for all by 2030 requires nearly \$1 trillion of total investment. While finding these funds may seem somewhat daunting, it is actually only 3% of the expected global energy-infrastructure investment over the same time period. Also, the IEA dismissed concerns that providing access to modern energy to all people would increase energy demand and CO₂ emissions excessively; projections showed that global energy demand and CO₂ emissions would increase by only 1% and 0.6%, respectively, in 2030 even if global access to modern energy was achieved. The figure to the right shows the number of people without access to electricity in 2010 in several key countries. The blue bars represent populations in developing

Asia and the orange bars represent populations in Sub-Saharan Africa. The cumulative share of the global number of people who lack access to electricity is shown using the green line and symbols.



Source: Reproduced from the IEA WEO2012 (available at www.worldenergyoutlook.org)

The Challenges of European Energy Infrastructure Finance

By Nicholas Newman

Contributing Author, *Cornerstone*

Energy infrastructure construction is expected to “take off” and undergo rapid growth in coming years. The world’s demand for global energy infrastructure investments is projected to reach some €421.14 billion in each year to 2030, of which 60% will be spent on electricity. Power generation as a whole will account for 46% and the remainder will be spread between transmission and distribution, according to the International Energy Agency.¹ Despite the European aspiration to decarbonize the power sector, coal-based power generation is increasing with some 1200 coal-fired power plants planned to be built in 59 countries.

There are many drivers of power infrastructure investment in Europe, chief of which is the commitment to decarbonize the



A Nuclear Power Plant at Grafenrheinfeld, Germany.
Source: Christian VisualBeo Horvat

“Despite the EU’s environmental policies, Europe is planning 69 new coal power plants with a capacity of 60 GW.”

electricity sector by 2030, although this objective is being undermined by the “dash for coal” which is widely available and whose price in relation to gas has crashed. Equally important is the state of the EU’s energy infrastructure which is aging and is unable to match future demand for energy, ensure security and diversity of energy supply, or support large-scale deployment of energy from renewables such as wind and solar. It is this factor that makes upgrading of the existing network and the development of new, intelligent, energy transmission imperative. In Europe, with its aging power generation and distribution infrastructure, power utilities will need to spend an estimated €1 trillion by 2020 on new infrastructure to secure and maintain power supplies. Out of this total sum €750 billion is needed for power generation alone, €90 billion for transmission lines, and at least €150 billion to expand gas supplies and build new pipelines.²

EUROPEAN ENERGY INFRASTRUCTURE INVESTMENT PROJECTS

Despite the EU’s environmental policies, Europe is planning 69 new coal power plants with a capacity of 60 GW, reports the World Resources Institute.³ Germany, notwithstanding the emissions trading scheme, plans to invest in 26 new coal-fired power plants to compensate for its sudden decision to phase out its nuclear power capacity. In Britain, there are applications to construct 4.9 GW of gas-generating capacity between now and 2020, according to government figures. In Europe, according to the World Nuclear Association, as of March 2013, some 23 nuclear power plants are at various stages of development, of which 10, with a total generating capacity of 9.2 GW, are destined for Russia.⁴

European investment to upgrade its energy distribution networks is a prerequisite for the creation of a single European energy

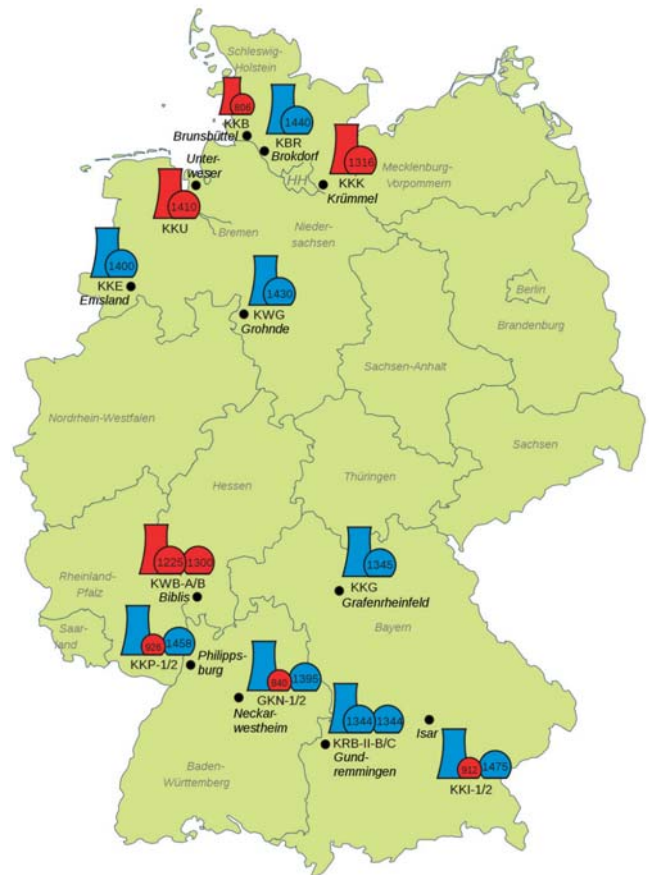
market for gas, oil, and electricity to overcome the current capacity issues and to allow cross-border energy trading. To facilitate ease of power-switching across Europe the Pike Research “Smart Grids in Europe” report⁵ of 2011 forecasts that, during the period from 2010 to 2020, cumulative European investment in smart-grid technologies will reach €61.48 billion. This “clean-tech market” firm anticipates that smart-grid revenue in Europe will peak at €7.5 billion in 2017 before declining somewhat to €6.97 billion by 2020.

At present, the European transmission grid for gas and electricity is incomplete. The plan to build three North-South power “autobahns,” or power corridors, to ship electricity from the North is well behind schedule. Furthermore, the grid is unready to absorb increasing energy from renewable sources, thus necessitating additional storage facilities; to obtain further improvements in integration, interconnectors are required to link the Baltic States with mainland Europe. Refurbishing, extending, and upgrading of existing transmission lines alongside the development of new energy transmission infrastructure will require investments of some €140 billion in electricity and at least €70 billion for gas by 2020.

The European Network of Transmission Operators for Electricity has outlined the total expected investment requirement for projects of pan-European significance by country to 2022. Under this scheme, Germany is required to invest €30.1 billion, Britain €19 billion, France €8.18 billion, Italy €7.1 billion, Norway €6.5 billion, and Spain €4.8 billion. The National Grid, which operates the high-voltage electricity transmission network in the UK, is required to invest £1 billion in additional North-South grid capacity in a new sub-sea power cable to link wind farms along the west of Scotland with Liverpool in England. This interconnector will be the longest 2200-MW capacity HVDC (high-voltage direct current) cable in the world.

SOURCES OF FINANCE

The two traditional providers of infrastructure project finance lending, governments and banks, are under severe financial constraints at a time when worldwide demand for capital to fund ambitious energy infrastructure modernization and expansion plans is increasing. Banks, which provide about two-thirds of global project finance, are being required by energy policy makers and energy companies to raise their capital ratios at the end of 2013. At the same time, deep-rooted solvency issues will restrict lending and raise the cost of their loans. Western governments, especially European, have already cut subsidies, introduced tariff cuts, and are unlikely to maintain the level of support for energy projects provided in previous years.



Map of the Nuclear Power Plants in Germany Shut Down Since the Fukushima Disaster. (Shut down reactors are in red, operating reactors are in blue.) Credit: Kernkraftwerke in Deutschland.svg: Lencer

Nevertheless, EU agencies such as the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB) will continue their support of Europe’s mega-infrastructure projects alongside sovereign wealth funds such as that of Norway and perhaps Russia. Given the scale of the demand for funds and the difficulties of traditional suppliers of finance, a shortfall in funding is inevitable. Europe is facing a €1 trillion shortfall in its energy network investment requirement over the next decade, according to a UK House of Lords Report⁶ released in May.

Funding the Gap

While capital market funding of infrastructure projects in Europe remains underdeveloped compared with America, Australia, and Canada, private equity investment, hedge funds, institutional investors, and specialist infrastructure funds

will contribute toward lessening the funding gap, since “infrastructure lending has become a mainstream asset class”.⁷ However, it is estimated that institutional investors will provide only about 10% of the €200.59 billion of project financing to be raised in 2013 in Europe.⁸ Lack of a clear policy within the EU and its member states on how to deliver secure energy and decarbonize power is holding back investment and raising uncertainty and risk for investors. For private investors and specialist funds, there is no long-term certainty over demand, energy policy, or the relative cost of fuels, power, or carbon prices. For instance, Europe’s demand for power has fallen by 1.2% a year since 2008, and coal is plentiful and cheap whereas gas is dear. The carbon price has collapsed from a high of €30 in April 2006 to just €2.75 in April 2013, leading to financial losses for many gas power plants. In addition, investors need to factor in political risk and uncertainty. There have been cutbacks in feed-in tariffs for solar projects in Britain, Italy, and Spain. The current British government increased taxes on oil and gas production from the North Sea and then subsequently reduced them. At the national level, European countries offer a hodgepodge of competing regulations and subsidies, making Europe-wide financing, energy trading, and switching difficult.

However, it is clear that often the first source of new finance will be the power utilities themselves supported by quasi-state-owned banks, such as the EBRD and the EIB. The UK has led the world in public private finance (PPI). Certainly, PPI projects are seen as a good way to secure construction contracts for construction companies, such as Skanska, one of the world’s leaders in such projects. Project developers, especially in the renewable sector, offer power purchase agreements (PPA) to provide security of returns to investors. In addition, some equipment manufacturers have set up their own dedicated funding subsidiary: for example, General Electric’s GE Energy Financial Services, which has invested \$20 billion in energy investment commitments worldwide. Together, these projects have a capacity to produce 30 GW of power—equivalent to the total installed generating capacity of Norway. Like several large energy technology providers, GE offers its customers a range of financial packages, including structured and common equity, project finance, leveraged leases, corporate finance, asset-backed revolvers, acquisition finance, and senior secured debt. Finally, sovereign wealth funds such as those in Singapore, Norway, and Russia have the funds to invest in the kind of mega-power projects Europe needs. For instance, the construction of Gazprom’s €6 billion Nord Stream gas pipeline linking the Russian gas grid with northern Germany was financed with 30% raised by the project partners Gazprom Wintershall, E.ON, Ruhrgas, Gasunie, and GDF Suez. The rest of the funding came from major banks such as Royal Bank of Scotland, Deutsche Bank, and Crédit Agricole S.A.

Financial Innovations

To meet the required scale of energy investment demand necessitates new sources of finance and financial instruments. In Britain, the government has established the Green Investment Bank. This quasi-public/private bank has been set up specifically to provide both green and commercial capital for green-related energy projects. Similarly, last November, the EIB launched a pilot Project Bond Initiative designed to stimulate capital market financing for infrastructure delivered under “project finance” structures, including PPIs. This initiative will seek to enhance the credit rating of bonds issued by project companies to a rating level that is attractive for investors and to lower the project’s overall financing costs. The pilot phase, lasting until 2016, will benefit to the tune of €230 million from the EU budget and will focus on encouraging capital market contributions worth more than €4 billion for infrastructure investment in the transport, energy, and communications sectors. However, in comparison with total lending of €61 billion by the European Investment Bank in 2012, this sum looks insignificant. It is widely expected that, in the future, insurance companies, financial advisory service companies, and pension funds will become mainstream investors in energy infrastructure as they seek higher, and hopefully secure, long-term returns in a world of low yields.

CAPACITY CONSTRAINTS

The opportunities for industries and companies involved in the design, planning, construction, and operation of power infrastructures are large and growing. Whether there will be capacity constraints and where they will emerge will depend upon the scale and timing of individual projects. Industry insiders point to an expected shortage of specialized engineers, which has driven costs higher and higher. This, and other potential shortages, will be exacerbated by the nature of infrastructure projects in energy generation, transmission, and distribution. These are large-scale schemes, requiring massive upfront investments, in which economies of scale are significant. Consequently, the companies and sectors most closely associated with such projects are large, often international or even global, and enjoy high barriers to entry. Insufficient finance has often been a cause of delays in construction for energy projects within the EU, most notably in the case of the Nabucco gas pipeline linking Austria via the Balkans and Turkey to central Asian gas fields. Equally, government indecision has contributed, and still is contributing, to delays in projects.

CONCLUSIONS

Government will remain a major player for its ability to guarantee projects, thereby reducing the cost of borrowing below standard commercial loans as well as fixing the minimum price of power. Given the financial constraints of the EU and European governments, it is probable that there will be an increase in public-private partnerships to deliver EU-wide priority energy projects. It is clear that the modernization of European transmission networks alongside new generating capacity will require substantial new sources of funds. However, as a result of the EU's financial and economic difficulties, important projects are being held up by longer-than-expected negotiations between ministries and companies over terms and rewards. For example, a lack of funding and insufficient government support has stalled the development of new offshore wind farms in the North Sea. The attractions of large-scale energy infrastructure investments are hampered by a climate of uncertainty surrounding both the EU and member states' energy policies. Indeed, as pointed out by Peter Atherton, of Liberum Capital, successive governments have "grossly underestimated the engineering, financial, and economic challenges posed by the drive to decarbonize the electricity sector by 2030".⁹ Such an EU-wide objective, while keeping the lights on and household fuel bills affordable, may, in the end, be politically impossible. The opposition of industry and of householders to paying for such an energy switch may prove incompatible with politicians' ambitions to be re-elected. Investors in energy infrastructure projects will feel the consequences. 🤖

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Will the ETS Survive?

The European Emissions Trading System (ETS) is the world's largest cap-and-trade market for carbon credits, and it is in trouble. Based on several factors, including the recent global financial downturn and the economic woes of some EU members, the number of emissions credits available to the market is far too high. From 2013 to 2020 it is estimated that there is an allotment of approximately an extra year's worth of credits available, which is dragging down the trading price. As recently as 2011, the credits were worth €20, but today prices have fallen well under €3 (US\$30 and US\$4.5, respectively).

The EU Commission proposed a plan to address the low prices—remove some 900 million tonnes of carbon allowances and return them to the market at some point in the future when (or if) the demand warranted it. However, this proposal was rejected by a slim margin in the European Parliament on 16 April. In the future, it will be important for the ETS to make a

recovery, or it could fail to help achieve any of the goals for which it was established. Some have theorized that if the ETS does not show improvement, carbon emissions in Europe eventually will be controlled on a national level, rather than by the EU.

Total amount of emissions allowed under ETS:
16 billion tonnes between 2013 and 2020.

In 2011 ETS credits were selling for
\$30 in 2013 they are below \$5.

Pollution Control of Coal-Fired Power Generation in China:

An Exclusive Interview with Wang Zhixuan

By Li Xing and Chen Junqi

Editors, Cornerstone



Wang Zhixuan is a Member of the Leading Party Group and the Secretary-General of the China Electricity Council. He is also a Member of the National Climate Change Expert Committee.

Q: *Coal-fired power generation plays a dominant role in the electricity mix in China, but it is also considered to be a significant source of air pollution. What is the current overall status of the emissions from coal-fired power generation in China?*

A: For a long time, coal-fired power generation has accounted for 75% of total power generation and the coal consumption for power generation accounts for half of the total coal use in China. Emissions of sulfur dioxide, nitrogen oxides, particulate matter, and other atmospheric pollutants from coal-fired power plants have been closely monitored by environmental protection authorities and have resulted in the most important limitations for the continued development of the power industry. Since the 1970s, with the increasingly heightened environmental protection efforts by the Chinese government and the rapid and constant growth of the power industry, coal-fired power plants have continuously improved their efficiencies and emissions control. This became particularly true after nearly a decade of the widespread adoption of emission control facilities; emissions have been under control, with the emissions per kilowatt hour catching up with that of world's most advanced countries.

"A coal-dominated energy mix in China is inevitable to ensure China's energy security."

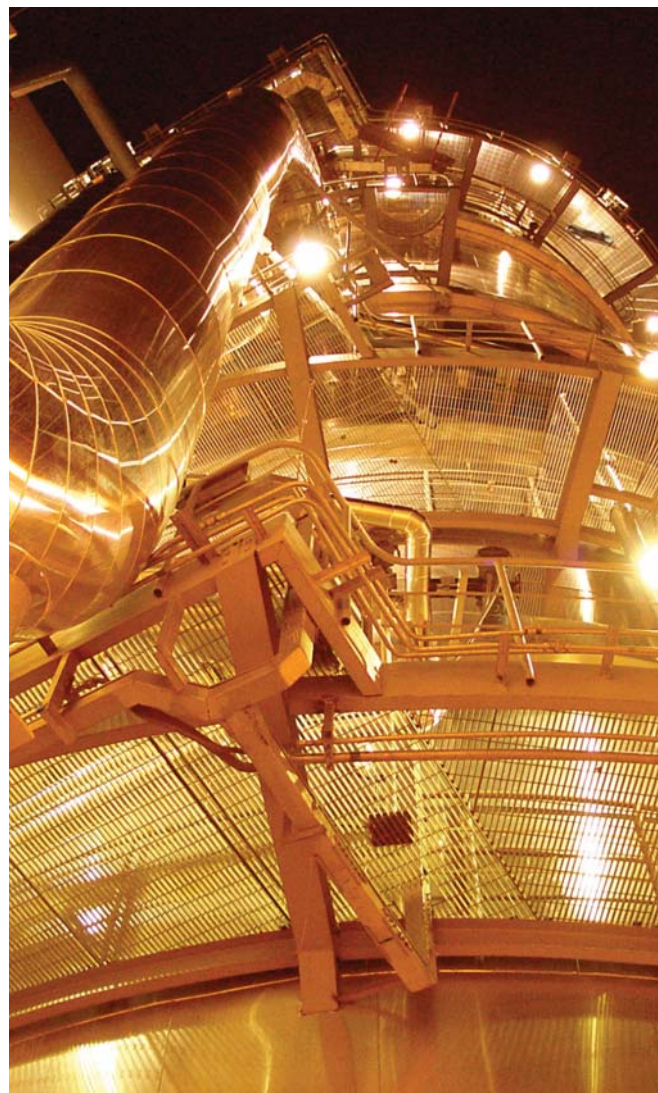
In terms of energy efficiency, by continuous construction of high-parameter, large-capacity units as well as elimination of small thermal power units, the nationwide average net coal consumption for coal-fired plants 6 MW and larger has been reduced from 471 gce/kW·h in 1978 to 326 gce/kW·h in 2012. The average energy efficiency, in terms of HHV, has increased from 27.6% to 37.7%.

The total annual discharge of particulate matter has been reduced from 4 million tonnes in the early 1980s to 1.5 million tonnes in 2012, and the emissions per unit power generation were consequently reduced from 16.5 g/kW·h to 0.4 g/kW·h. Particulate matter controls have also been upgraded to include higher efficiency electrostatic precipitators (ESP), fabric filters, as well as ESP and fabric filter hybrid systems compared to the formerly used, less efficient mechanical and water film-based systems. The average dust collection efficiency was increased from 90% in 1985 to 95% in 1995, 98.5% in 2005, and 99.6% today. Currently, the efficiency of new particulate matter collectors is generally better than 99.9%; ESPs make up approximately 90% of installed particulate control systems, while fabric filter and hybrid systems account for the other 10%.

The rapid decrease in sulfur dioxide emissions began in 2005 when desulfurization facilities were widely applied. Sulfur dioxide emissions were reduced from 13 million tonnes in 2005 to 8.83 million tonnes in 2012; sulfur dioxide emissions per unit electricity were reduced from 6.4 g/kW·h to 2.26 g/kW·h, which is better than the 2.8 g/kW·h recorded in the U.S. in 2011. Presently, desulfurization is applied to approximately 90% of all coal-fired power plants in China, which is approximately 30 percentage points higher than that of the U.S. in 2011. If we take into account circulating fluidized bed boilers, which include integrated desulfurization, as well as subtracting units that are slated to be closed, desulfurization will be applied to nearly 100% of coal-fired power plants in China.

Since 1996, China's coal-fired power plants have operated with low NO_x combustion techniques to reduce emissions. Starting in 2010, as required by the pollution control program and the newly revised Emission Standard of Air Pollutants for Thermal Power Plants, power plants increased the installation of flue gas denitration systems, and the discharge of nitrogen oxides has decreased from 10.03 million tonnes in 2011 to 9.48 million tonnes in 2012. NO_x emissions per unit electricity have decreased from 2.6 g/kW·h to 2.4 g/kW·h. By the end of 2012, China had put into operation flue gas denitration units on a total power plant capacity of approximately 230 GW, which accounts for approximately 28.1% of all coal-fired power plants in China. The power plant capacity where addition of flue gas denitration units are under planning and construction exceeds 500 GW.

Q: From the second half of last year to the first half of this year, a wide range of hazy weather has prevailed in many parts of China. Reports have stated that this hazy weather was related to PM_{2.5}, and the source of PM_{2.5} is mainly from coal-fired power plants. Can you frame the relationship between coal-fired power plants and PM in a scientific perspective?



Desulfurization Scrubbers, Such As This One Operated by Shen-hua Guohua, Are Being Added to Coal-fired Power Plants to Meet the New Emissions Standard

A: The hazy weather is indeed related to PM_{2.5}, but the increase in the number of hazy days in China has shown a growing trend, which is related to coal-fired power plant emissions and also to increased deployment of motor vehicles and the growth of urbanization. In general, the haziness is caused by pollution associated with urbanization and industrial pollution.

Unquestionably, coal-fired power plant emissions will significantly impact the environmental quality in a region; the effects are felt most prominently near the emissions source. However, the impact of coal-fired power plant emissions should be assessed and evaluated scientifically, or it could mislead

decision making directed toward controlling the haze pollution. I believe that the atmospheric pollutants produced from coal-fired power plants are not the primary cause of the hazy weather. First, it's extremely unscientific and irresponsible to calculate coal-fired power plants' emission ratio based on the coal's proportion of combustion, because the quantity of emissions mainly depends on the effectiveness of the emissions control. Second, the quantity of emissions discharged will not directly determine the impact to the environment or the impact to creating haze; the matter of where and how the emissions are discharged should be considered as well. For example, emissions to the air and hazards to human health from the pollutants emitted from running vehicles on city roads are most certainly orders of magnitude higher than the equal quantity of pollutants produced from thermal power plants distant from the city. Therefore, the nearby emissions in the city would be more conducive to the forming of $PM_{2.5}$. It also can be proven that coal-fired power plants are not the main source of $PM_{2.5}$ according to the following several points:



The Haze in Beijing is Often Attributed to Coal-fired Power Plants, But Analysis Has Shown This May Not Be the Case

First, regarding the fine particle matter produced directly from coal-fired power plants, even if everything produced by the plants was $PM_{2.5}$, the total annual discharge would be about 1.5 million tonnes, which would make little contribution to the forming of haze. For example, the coal use for power plants in is only 4.13% of the total coal use city-wide. The annual PM_{10} emissions from coal-fired power plants (including $PM_{2.5}$ emissions) amount to only 0.005% of total PM_{10} discharged in the area.

Second, regarding sulfur dioxide and nitrogen oxides, which indirectly form $PM_{2.5}$, in recent years the discharge of sulfur dioxide has been substantially reduced with basically flat levels of nitric oxide, but on the contrary, the hazy weather is increasing.

Third, thermal power plants often have dispersed emissions due to the height of the stack, which is usually 210 m or 240 m in height, with an additional plume rise of 400–500 m. Plants with such tall stacks play a minor role in impacting environmental quality and the forming of hazy weather.

Fourth, over the years, China has banned the construction of new coal-fired industrial boilers except plants that provide heat to urban areas. This is despite the fact that coal-fired power plants built in old towns are used as a substitution for most scattered coal-fired heat sources and create a significant opportunity for improving the city's environmental quality. Today, there are approximately 600,000 industrial boilers in China that still use coal-fired boilers and direct coal firing for heating; most of these are in residential areas in urban centers in north China. Taking Beijing as an example, there are still 44,000 households with coal stoves in the western district within 2nd Ring Road; the impact of urban environmental pollution caused from these coal stoves is direct and severe.

Q: The Ministry of Environmental Protection of the People's Republic of China (MEP) issued the revised Emission Standard of Air Pollutants for Thermal Power Plants at the beginning of 2012. Currently, this standard has been formally implemented for power plants. Emission limits for nitrogen oxides, sulfur dioxide, particulate matter, etc., in the new standard are close to or have reached the limits set in most developed countries. Furthermore, the new standard includes an emission limit for mercury. Can you discuss the current status of implementation of the standard for the existing fleet of coal-fired power plants?

A: After the standard was issued, the power industry initiated a new round of large-scale flue gas denitration, desulfurization, and particulate matter control technology development and construction. Taking denitration as an example, denitration

control was placed into operation in 2012 on nearly 90 GW worth of power plant capacity. Furthermore, in 2012, most units that will require denitration-related improvements began the modifications and construction. In the next three years, there will be a peak in denitration equipment construction. It is predicted that the power plant capacity with denitration could be up to 500 GW. At the same time, based on the requirements set in the emission standards, many power plants will still require desulfurization and particulate control improvement to meet the standard emission limits, including about 500 GW of plants with particulate control efficiency improvements and about 300 GW of desulfurization efficiency improvements.

Even with this progress, implementation of the new standard still faces several challenges. First, the standard is too strict overall, and some requirements are stricter than those in any other nation. It is difficult to meet the standard with existing technologies while maintaining stable power-plant operation. Second, the limits are unreasonable from an economic perspective. From the viewpoint of reducing society-wide pollution, with most other industries having little to no emissions limits, the standard applied only to power plants may result in excessive costs and result in less environmental protection because the standards are applied only to power plants. Third, the revision cycle for the power plant emission standard is too short. Comprehensive benefits may be lessened if control technologies must be reexamined and upgraded every few years. Furthermore, there is technical difficulty associated with implementation of the control technologies. With regards to what is technologically achievable, the standard is unreasonable and unscientific. Fourth, the implementation time to meet the standard is too short. Consequently, the environmental controls industry will have difficulty providing the necessary support to the power producers, there will not be enough time for technology selection, and the quality of the systems will be difficult to guarantee. From the perspective of the implementation schedule, it will be very difficult to complete the upgrades necessary to completely meet the standard before July 2014.

Considering control of mercury emissions from coal-fired power plants, mercury will mainly be controlled through the co-benefits from existing desulfurization, denitration, and particulate removal. Based on mercury removal demonstrations in China, mercury emissions from the coal-fired power plants that have taken an emission test can generally meet the emission standard. In addition, particulate removal and desulfurization in China are competitive with the world's best. The average denitration efficiency is expected to increase to 80% or more in 2015. Therefore, co-benefit control of mercury emissions will also increase accordingly.



A man using a tricycle to transport coal rides past a panda sculpture during severe pollution on 23 January 2013 in Beijing, China. (Photo by Feng Li/Getty Images)

Q: What's your opinion on the role of coal-fired power generation in medium- and long-term energy supply mix and state environmental protection work in China?

A: A coal-dominated energy mix in China is inevitable to ensure China's energy security. Therefore, to reduce environmental pollution to the greatest extent, a similar proportion of improvements to coal-fired power plant emissions and implementation of clean coal power generation are also inevitable. Chinese coal consumption for electricity generation accounts for a little more than 50% of all coal consumption, which is far lower than the percentage in developed countries and even the global average. For example, the percentage of coal use for electricity in the U.S. accounts for about 90%, Canada 85%, Germany 81%, the UK 75%, Russia 64%, and the global average is approximately 78%. China should increase the proportion of coal used for electricity, and also increase the proportion of electricity as the source of end-use energy consumption.

As technology continuously progresses and the economy grows, traditional electricity from coal will gradually move toward cleaner coal conversion. The ideas for the future of coal-based electricity will be based on conventional units, supercritical and ultra-supercritical units, and development of IGCC, CCUS, and 700°C cogeneration and polygeneration units, which all take into account carbon dioxide emission reductions and effective

resource utilization through higher efficiencies. New coal-fired power plants with higher efficiencies will address carbon dioxide emissions and effective resource utilization. From the perspective of environmental protection, coal-based electricity will play an important role in national environmental protection and further control haze. Theory and practice have proven that in a coal-dominated energy mix, the higher the ratio of emissions from the electric industry, the better the overall energy mix is and the lower total emissions will be (i.e., because more large coal-fired power plants mean fewer small coal-fired boilers and less direct coal-firing for heating). China should promote replacing small and scattered coal-fired power plants and coal-fired heat providers in cities actively, and effectively promote the development of electricity from coal and electricity instead of oil and urban electric vehicles.

Coal resources are set, so China should encourage power plants using low-quality coal and/or high-sulfur coal to simultaneously strengthen their emissions controls systems, and efficiently control emissions while not mandating power plants to use low-sulfur coal. When plants use high-quality coal, emissions could be reduced, but in reality high-sulfur coal will be used by small companies, which is more likely to result in increasing pollution. When coal is converted to electricity, coal-fired power plants should improve emissions control through the application of technology and enhance the operation management of particulate control, desulfurization, and denitration systems to ensure reliable emission removal efficiency. 🔄

Anthracite: An Increasingly Valuable Commodity

Anthracite, the highest quality coal with the greatest carbon and energy content, represents only 1% of world coal reserves. Anthracite is increasingly sought for use as an ultra-low volatile pulverized coal injection ("PCI") product to reduce the amount of higher priced coke consumed in the manufacture of crude steel. Coarse anthracite is also used as a direct coke replacement to reduce blast furnace consumption of metallurgical coke, and as a blend coal with hard coking coal in the manufacture of coke. It is the only coal that can be used as sinter feed, and its low volatile content is key to its use in electric arc/direct reduction steel manufacturing and the processing of ferroalloys and other metals. The very high carbon content of anthracite is preferred for numerous coal gasification/liquefaction technologies to make synthetic fuels, plastics, and urea fertilizers. It also explains why anthracite is used for water purification and to make some carbon composite materials. Additionally, coal-fired thermal power plants configured to burn anthracite have lower greenhouse gas emissions than those using lower quality coals.

China is by far the dominant producer of anthracite with annual production of more than 500 million tonnes, representing more than 80% of global production. Since 2004, China has been a net importer. Vietnam, currently the largest exporter, is implementing a policy to restrict exports to 5% of its 45-million-tonne annual production. Anthracite production is in danger of not being able to keep up with demand.

Recently, Canada's Fortune Minerals Limited (80%) and South Korean steel producer POSCO (20%) formed a joint venture to develop Canada's first anthracite coal mine: the Arctos Anthracite Project. Arctos is located in northwest British Columbia, about 330 km northeast of the port of Prince Rupert, the primary export point to Asian steel manufacturers and metal processors. Arctos is one of the largest anthracite projects being developed to service the growing metallurgical, chemical, and thermal markets at a time when availability of anthracite from traditional sources is declining. A picture of the Arctos coal seam is shown below.



The Rio Summit: Waking Up to the Three Pillars of Global Poverty, Energy Access, and Coal

By Benjamin Sporton

Deputy Chief Executive, World Coal Association

Halving global poverty was the centerpiece of the Millennium Development Goals adopted by the United Nations in 2000. An ambitious goal, it was adopted among a range of other development goals to fight the extreme poverty and hunger experienced across the developing world. Early in 2012, as the world began to prepare for the Rio+20 United Nations Conference on Sustainable Development, the World Bank and United Nations announced that, in fact, this goal had been met. “The developing world as a whole has reached the first of the millennium goals,” said Martin Ravallion, a senior World Bank official.



Sha Zukang, Secretary-General of the Rio+20, Listens as Ecuador's President Rafael Correa Addresses the UN Conference on Sustainable Development, or Rio+20, in Rio de Janeiro, Brazil, 21 June 2012. (AP Photo/Victor R. Caivano)

“As a whole” was an interesting choice of words. The true story is a little different. In the past 30 years, in fact, the number of people living in extreme poverty in the developing world has remained stagnant, at around 1.1 billion, most of these in Africa and Latin America. The real story about lifting people out of poverty has come in East Asia, and particularly in China. In that same 30 years, China’s economic boom has seen 662 million people lifted out of poverty, a huge achievement by any measure.

ELECTRIFYING CHINA

China’s poverty alleviation effort has been built upon massive improvements in basic infrastructure and the creation of local enterprises, enabling a productive workforce that continues to drive wealth creation and poverty eradication across the country. None of this could have been achieved without an immense electrification program that has brought electricity to 99% of China’s population, adding around 1500 terawatt hours of production capacity in the last 20 years.

How has that massive expansion in electricity and infrastructure been achieved? It is by now a well-known answer: China has used its significant coal reserves to fuel its expanded energy supply and to make the steel to build its growing cities and industries. No other development strategy has proved more successful in lifting people out of poverty. However, this is a lesson often overlooked.

“In the past 30 years...the number of people living in extreme poverty in the developing world has remained stagnant, at around 1.1 billion, most of these in Africa and Latin America.”

BALANCING THE THREE PILLARS

Last year's Rio+20 conference was billed as the 20th anniversary of the Rio Earth Summit in 1992; taking another view, however, it was actually the 40th anniversary of the original Stockholm Summit on Environment and Development held in 1972. More than 40 years and countless international conferences since this original summit, world leaders still struggle to define a pathway to the eradication of global poverty.

One challenge in defining that pathway has been the difficulty in finding balance between the three pillars of sustainable development—economic, environmental, and social sustainability. With growing concern about environmental degradation and the impacts of climate change, the developed world has focused heavily on environmental aspects of development, whereas the challenge of poverty eradication means much more focus is placed on economic aspects of sustainability in the developing world. It's a tension that has prevented progress in attempting to negotiate both environmental and development treaties for decades.

No clearer has this dichotomy presented itself than in debates about access to energy. Four billion people struggle with energy poverty, including 1.3 billion with no access to electricity at all and many more that rely on wood and dung for cooking and heating. It is well known, as the story of China shows, that access to energy is a critical element for lifting people out of poverty. It's for this reason that 2012 was declared by the United Nations as the International Year of Sustainable Energy for All, and that energy access was a major topic of discussion in preparations for last year's Rio summit.

It is regrettable, though, that international talks about energy access have been caught in that historical wrangle between environmental and economic progress. Debates on energy leading into the Rio summit saw a huge focus from the UN agencies and the developed world on renewable energy sources being the primary tool with which to tackle energy poverty. It is true that renewable energy will have a big role to play in achieving energy for all, but many in the developed world have focused exclusively on these sources due to their overriding environmental priorities. The victim of this focus was a truly ambitious outcome from the Rio conference on energy access.

TARGETING ENERGY ACCESS

Many commentators have lamented that the Rio conference failed to agree on, or even support, a specific target for delivering energy to those who lack access to it. This is

disappointing. The risk, however, was that such a target might lack any true ambition. The early draft of the Rio outcome document referred to a "basic minimum level" of energy access, but what does this mean? According to the definition proposed by the International Energy Agency (IEA), it is defined as "use of a floor fan, a mobile phone, and two compact fluorescent light bulbs for about five hours a day" in rural areas and in urban areas perhaps also "an efficient refrigerator, a second mobile phone per household, and another appliance".¹ That is not the sort of energy access target that the developing world needs, and it is certainly not the type of energy access that has supported the huge growth in China's economy in recent decades. That is because targets like this one specifically exclude consideration of energy supplies for business, industry, and social infrastructure.

A recent study demonstrated the scale of the challenge when it comes to providing comprehensive energy access. Looking at sub-Saharan Africa (excluding South Africa), the study highlighted the need for a twelvefold increase in electrical generation capacity in the region, from the current 31 GW of installed capacity to about 374 GW, to meet even a moderate access scenario (see Figure 1).² Such a scenario would be a truly positive transformation for the region—economically, socially, and, importantly, environmentally. That is despite such a scenario continuing to leave the population of sub-Saharan Africa well short of the sort of electricity supply demanded by those of us in the western world.

The real challenge for policy makers across the globe is how to meet this demand for energy. The IEA has assessed the energy sources needed to meet their own minimal "energy for all" scenario.³ Their assessment shows that roughly 840 terawatt hours of generating capacity is needed, just over half

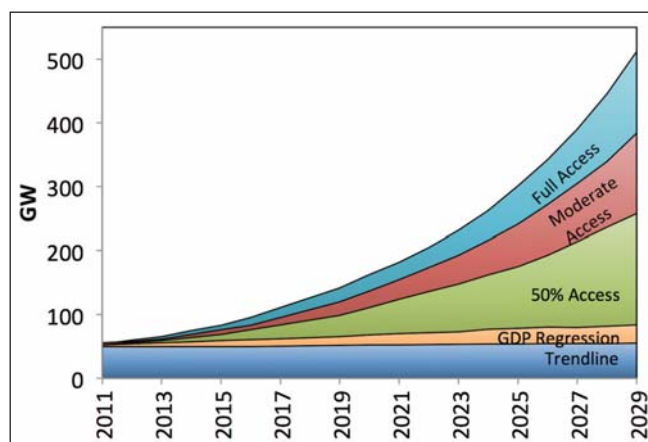


FIGURE 1. Scenarios and Projections for Installed Power Capacity in Sub-Saharan Africa²

of which would be provided in mini- and off-grid solutions. All but a small proportion of the off-grid component is expected to come from renewable energy. This is what some have described as the “cook stove and light bulb” solution to energy access, where wind and solar are deployed to provide basic access to energy. Yes, this approach can provide cleaner cooking solutions in the home and reduced household pollution from burning wood, dung, and charcoal in the home—leading to improved outcomes; it also provides lighting to improve household productivity and educational outcomes. It is an important, short-term first step in addressing energy poverty. But it cannot be the maximum of global ambition on achieving energy access.

THE ON-GRID SOLUTION

It is the makeup of the on-grid part of the IEA’s energy-for-all scenario that points toward what a more ambitious energy access target might look like (see Figure 2). Coal is the key component of the on-grid solution in the IEA’s energy access target. According to their report, more than half of the on-grid electricity needed to meet their minimal energy-for-all scenario will come from coal, and that is telling. Grid-based electricity is essential to provide reliable supplies of electricity that avoid the intermittency of off-grid renewables. Without grid-based electricity, households, industry, and business cannot rely on electricity, and this places economic security at considerable risk.

Why is coal so critical to this solution? There is a stark reality when it comes to looking at where the real energy access challenge exists, and the resources that exist in those regions (see Figure 3).

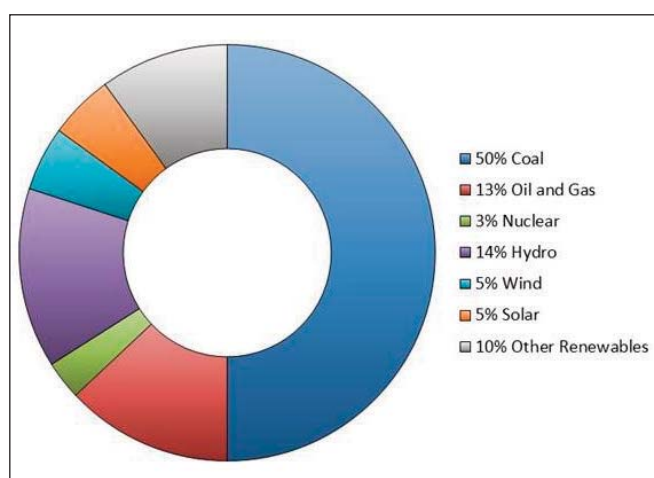


FIGURE 2. Additional On-Grid Generation Necessary for Energy Access for All³

Africa, India, and developing Asia are where almost all of the world’s energy poor can be found. Each of these regions also has huge coal reserves available to meet the energy access challenge. One of the major outcomes from the Rio conference was recognition that countries are entitled to choose their own energy mix based on national policies and priorities and their financial and, critically, natural resources. This recognition needs to be sustained into the future to enable countries to truly address their energy needs in an affordable way.

SETTING SUSTAINABLE DEVELOPMENT GOALS

The next steps from the Rio conference will see preparation of a new set of Sustainable Development Goals to come into effect beginning in 2015. These goals will be successors to the Millennium Development Goals, which lack any reference to energy access targets. There will need to be a concerted effort to ensure that these new goals recognize the different pathways countries can and will choose to achieve their energy futures based on their own resources. This will be a major debate over the next few years.

The new Sustainable Development Goals will, of course, come with significant environmental targets. Clean energy will be a key part of meeting those environmental targets, particularly as the international community seeks to reduce carbon emissions to avoid dangerous climate change. It may come as a surprise to some environmental groups, but that is why coal’s role cannot be ignored as part of this solution.

The first objective must be economic development supported by energy access. To meet environmental objectives the goals must support moves to a low-carbon economy in the most effective and affordable way possible, while meeting the significant energy and development needs across the globe. Attempts will be made to focus exclusively on the role of renewables, moving beyond any fossil fuel capacity. But this would be a misguided approach. Removing coal from the mix would make addressing the energy challenge prohibitively expensive—and would also fail to recognize that coal is part of the low-carbon solution.

Highly efficient modern supercritical and ultra-supercritical coal plants emit almost 40% less CO₂ than subcritical plants. This makes them a critical part of the arsenal to reducing global carbon emissions while meeting the world’s energy needs. The role these plants can play needs to be recognized and supported. Although more efficient, these plants are also more expensive. International support is needed to help deploy this advanced technology. Less efficient technologies

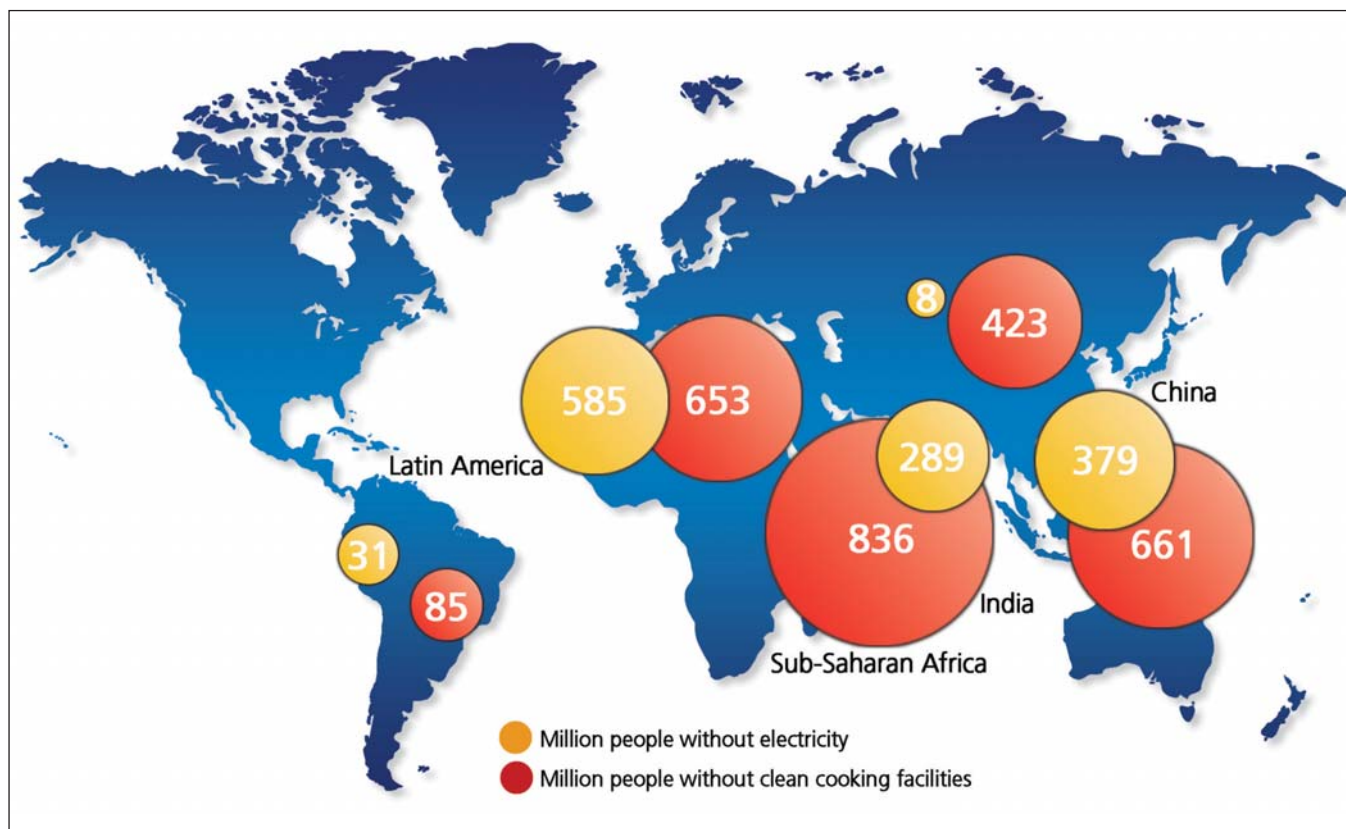


FIGURE 3. Number of People without Modern Energy Access³

with greater environmental consequences are likely to prove more attractive on a cost basis than more expensive but also more efficient and cleaner technologies to developing countries who do not receive international support. In the longer run, the same will be true of carbon capture technology. It is in these areas that the Sustainable Development Goals and action by multilateral development banks are critical.

India and countries in Africa and Asia will rightly want to use their own coal reserves to meet their energy needs and fuel their economies. They must be allowed to do this because it is the most affordable and effective pathway for them, but they also must be supported to do so in a way consistent with environmental objectives.

Sustainable Development Goals must recognize the reality of the huge energy needs in the developing world. These needs must be met using affordable and reliable technologies based on national priorities and resources. The goals, and the post-2015 development framework that supports them, must also recognize that, without the support to use their own domestic resources in an efficient and environmentally sound way, economic goals will likely take precedence over environmental

ones in developing countries. This would be regrettable because the two objectives should be integrated priorities for both the developed and developing world. 🌱

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What Will New U.S. DOE Leadership Mean for Energy?

By Nancy Lamontagne
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On 4 March, U.S. President Barack Obama nominated Ernest J. Moniz as Secretary of Energy. The Senate Committee on Energy and Natural Resources approved the nomination in early April, and on 16 May the full Senate unanimously confirmed Moniz. Moniz will bring his expertise in energy policy and research to lead the Department of Energy (DOE), which supports science and technology development that addresses energy, environmental, and nuclear challenges in the U.S. For the coal industry, Moniz's support of the expansion of natural gas may lead to concern. However, he has also been heard discussing CO₂ capture, utilization, and storage (particularly the utilization factor with nods to enhanced oil recovery [EOR]).



Energy Secretary Nominee Ernest Moniz, of Massachusetts, Testifies on Capitol Hill in Washington. The Senate Has Unanimously Confirmed President Barack Obama's Nominee to Lead the Energy Department. (AP Photo/Manuel Balce Ceneta, File)

Moniz is a physicist by training, graduating summa cum laude with a Bachelor of Science degree in physics from Boston College and earning a doctorate in theoretical physics from Stanford University. He is no stranger to public service, having served during the Clinton Administration as Associate Director for Science in the Office of Science and Technology Policy in the Executive Office of the President from 1995 to 1997. He also gained DOE experience as Under Secretary of that department from 1997 until January 2001, where he had oversight of the science and energy programs, led a comprehensive review of nuclear weapons stockpile stewardship, and served as the Secretary's special negotiator for Russian nuclear materials disposition programs.

"DOE has a central role in advancing the science and technology foundations for the transition to a low-carbon energy system that serves the nation's economic, environmental, and security goals."

During his opening statement before the Senate Committee on Energy and Natural Resources, he echoed the President's sentiment that the U.S. can produce more energy and grow its economy while still taking care of its air, water, and climate. "The need to mitigate climate change risks is emphatically supported by the science and by many military and religious leaders as well as the engaged scientific community," he said.¹ (Unless otherwise noted, quotes are from Moniz's testimony before the Senate ENR Committee.)

INNOVATION AND RESEARCH

Moniz believes in supporting research that advances technology with the goal of a low-carbon economy. When he returned to the Massachusetts Institute of Technology (MIT) in 2001, he focused on energy technology and policy,

especially research and education aimed at a future low-carbon economy. “Progress in energy science, technology, analyses, and policy is a preeminent challenge for the 21st century,” said Moniz. “DOE has a central role in advancing the science and technology foundations for the transition to a low-carbon energy system that serves the nation’s economic, environmental, and security goals.”

“As we go to a low carbon economy we really have to push hard on completing the investments that have been made, nearly six billion, on establishing CCS as a viable and cost-competitive approach.”

During the hearing, Moniz emphasized the important role of DOE’s research and development, drawing attention to the more than a hundred Nobel Prizes resulting from DOE-associated research and its role as a leading funder of basic physical science research and in providing unique research opportunities at major facilities for nuclear and particle physics, energy science, materials research and discovery, large-scale computation, and other disciplines.

“The Secretary of Energy has the responsibility for stewardship of a crucial part of the American basic research enterprise,” Moniz stated. “If confirmed, I will work with the scientific community and with Congress to assure that our researchers have continuing access to cutting-edge research tools for scientific discovery and for training the next generation.”

Moniz advocated for research and development that aims to lower the cost of energy. “In the end, the goal of innovation in this space is to reduce the cost so that we can have the lowest energy costs across the board,” he said. He also acknowledged budget constraints, saying that he would leverage funding as much as possible to move technologies to the point where the private sector can develop them into material contributors to a lower carbon economy. Moniz also said that demand side activity is extremely important and that technology development as well as incentives could help improve energy

efficiency. “If one looks at a low carbon future, it is hard to see how that could happen without efficiency gains,” he said.

ALL OF THE ABOVE

Moniz supports President Obama’s all-of-the-above energy strategy, which aims to reduce the country’s dependence on foreign oil by developing all energy sources: oil, natural gas, clean coal, biofuels, wind, solar, and nuclear sources of energy. Moniz said that, if confirmed, he would pursue the President’s strategy with the highest priority. “DOE should continue to support a robust R&D portfolio of low-carbon options: efficiency, renewables, nuclear, carbon capture and sequestration, energy storage,” stated Moniz.

Moniz is the founding director of the MIT Energy Initiative (MITEI), which links science, innovation, and policy to help transform global energy systems. The research program that he directs there reflects an “all-of-the-above” commitment by encouraging innovation around today’s energy systems as well as technologies for the future. Under Moniz, MITEI supported almost 800 research projects at the Institute and has 23 industry and public partners supporting energy research and analysis.

The largest single area of emphasis for MITEI is solar energy, followed by environmentally responsible hydrocarbon production and conversion. “If confirmed, I hope to be able to build on this experience [at MITEI] so as to convene industry, environmental groups, academia, investors, policy makers, and other stakeholders for constructive and consequential discussions about America’s energy future,” he said in his opening statement to the Senate committee.

CLEAN COAL

Despite the many new regulations facing the coal industry today, coal is mentioned as part of President Obama’s all-of-the-above energy strategy, and, during the hearing, Moniz confirmed his view that coal will continue as a major part of the energy supply in the U.S. and the world. He emphasized the importance of carbon capture and storage (CCS) demonstration projects, which have had a slow start in the U.S. Projects are planned in Texas, Mississippi, California, and Illinois but are not yet operational.

“As we go to a low carbon economy we really have to push hard on completing the investments that have been made, nearly six billion, on establishing CCS as a viable and cost-competitive approach,” Moniz said during the hearing. He outlined two major tasks for making coal competitive:

providing public confidence in long-term storage of large amounts of CO₂ through the various demonstration projects and focusing on innovation aimed at reducing the cost of carbon capture dramatically.

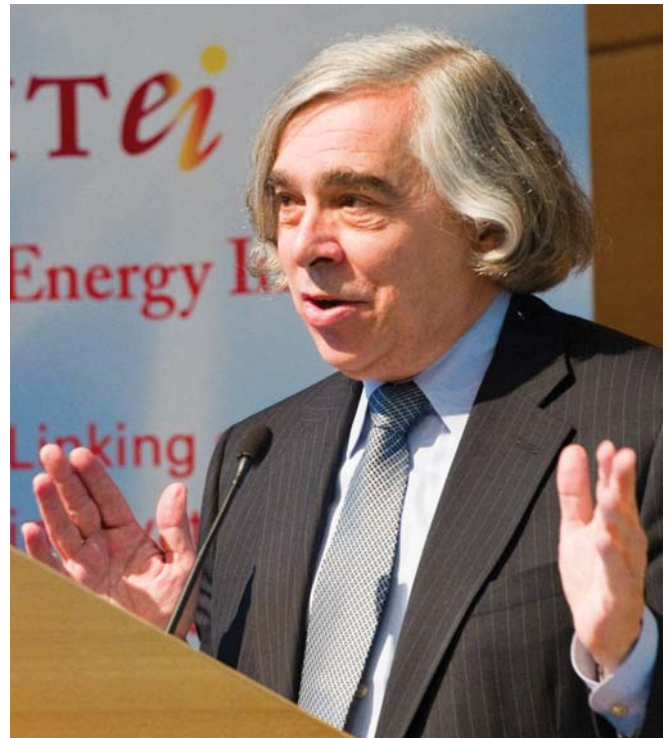
Moniz co-chaired a 2009 MIT symposium on retrofitting coal-fired power plants to capture CO₂ emissions, the findings of which are summarized in the MITEI report *Retrofitting of Coal-Fired Power Plants for CO₂ Emissions Reductions*.² “There is no credible pathway toward prudent greenhouse gas stabilization targets without CO₂ emissions reduction from existing coal power plants,” said Moniz when announcing the report. “We urgently need technology options for these plants and policies that incentivize implementation. We may not see a strong CO₂ price signal for many years. In the interim, we need a large, focused, federal program to develop and demonstrate commercial-scale technologies.”²

Among the report’s findings was that the federal government should dramatically expand the scale and scope for utility-scale commercial demonstration of coal plants with CO₂ capture, including demonstration of retrofit and rebuild options for existing coal power plants. To be effective, such a program would require new government management approaches with more flexibility and new funding approaches with greater certainty.

The MITEI report also stated that research and development for existing coal plants should focus on reducing the cost of post-combustion capture, which is essential for making retrofits affordable in developing countries. Research and development should also include efficiency upgrades, rebuilds, repowering, polygeneration, and cofiring with biomass. The report outlined that a robust U.S. R&D effort will require about \$1 billion per year for the next decade (not including support for commercial-scale demonstration). The report also said that consideration should be given to including a component for research on CO₂ capture from natural gas power plants, which Moniz also mentioned during the hearing, saying that even natural gas would require capture in a very low-carbon economy. If Moniz is willing to support substantial investments in CCS, there is hope that he will continue to support clean coal as an important component of the U.S. energy mix.

CO₂ FOR EOR

Under Moniz’s leadership, the MITEI issued the 2010 report *Role of Enhanced Oil Recovery in Accelerating the Deployment of Carbon Capture and Sequestration*, which summarized findings from a symposium on the same topic.³ The report says that anthropogenic CO₂ capture, transportation, and use for



Credit: Justin Knight, Courtesy of the MIT Energy Initiative

enhanced oil recovery (EOR) could significantly contribute to oil production in the U.S., and that increasing CO₂ capture several-fold from currently injected volumes could allow it to accommodate anticipated sequestration needs for at least a couple of decades. The economic benefits of EOR could offer a major stimulus for advancing CO₂ capture projects.

The symposium presenters and participants strongly urged DOE to develop and implement a research, development, and demonstration program that

- Provides data on permanence of CO₂ storage in EOR
- Develops tools for end-to-end systems analysis of CO₂ capture at power plants, transportation infrastructure, and stacked storage
- Provides an analytical framework for the value proposition for power plant, pipeline, and EOR operators and for the government
- Puts forward principles for resolving regulatory issues, such as pipeline siting and access, long-term liability, and pore rights
- Explores the potential for EOR in residual oil zones
- Maps out a phased implementation program for CO₂-EOR, including build-out of transportation infrastructure

FUTURE OF NATURAL GAS

A major cause for concern for the U.S. coal industry is Moniz's support of increased natural gas production, an enthusiasm that continued in this Senate hearing. In his opening statement Moniz acknowledged the stunning increase in domestic natural gas and oil production over the last four years. "The natural gas 'revolution' has led to market-led reductions in carbon dioxide emissions as well as a dramatic expansion of manufacturing and associated job opportunities," he said.

During the hearing he referred to natural gas as a bridge to a low-carbon economy for the U.S., pointing to the role of this energy source in making 2012 the year with the lowest energy-related CO₂ emissions in the U.S. since 1994, according to the U.S. Energy Information Administration (EIA). The EIA reported that low natural gas prices, particularly in spring and early summer of 2012, led to competition between natural gas- and coal-fired electric power generators. The lower natural gas prices led to reduced coal generation and increased natural gas generation, shifting power generation to the least carbon-intensive fossil fuel (natural gas).

"In the end, the goal of innovation in this space is to reduce the cost so that we can have the lowest energy costs across the board."

In terms of exporting natural gas, he said that, if confirmed, he would more closely examine the current situation in terms of applications and would look at each on a case-by-case basis, keeping in mind cumulative impacts and using a transparent, analytically based decision process. He emphasized the need for strong analysis regarding natural gas that is grounded in the best and most relevant data and also said that it was important to have public confidence in environmental stewardship as this resource is produced.

QUADRENNIAL ENERGY REVIEW

Moniz serves on President Obama's Council of Advisors on Science and Technology (PCAST), an advisory group of the nation's leading scientists and engineers who directly advise the President and the Executive Office of the President. At the

end of 2010, PCAST released the *Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy*,⁴ recommending an Administration-wide Quadrennial Energy Review (QER)—with DOE in the executive secretariat role—that could establish national goals and coordinate actions across agencies as well as identify the resources needed for the invention, development, and adoption of new energy technologies options, and policy options such as incentives and regulations to facilitate these activities.³

The DOE Quadrennial Technology Review (DOE-QTR) issued in September 2011 was an initial step toward a government-wide QER. It assessed the Department's energy technology research and development portfolios and established a framework for the Department's energy technology activities. Its findings included:

- DOE should give greater emphasis to the transport sector relative to the stationary sector.
- Among the transport strategies, DOE will devote its greatest effort to electrification of the vehicle fleet, a sweet spot for pre-competitive DOE R&D.
- Within the stationary heat and power sector, the Department should increase emphasis on efficiency and understanding the grid.
- The Department needs to develop stronger, more integrated policy, economics, and technical analyses of its research and development activities.

During the hearing Moniz said that he plans to build on the DOE-QTR foundation by working with colleagues across the Administration, garnering strong input from the Congress and private-sector stakeholders, and enhancing the Department's analytical and policy planning capabilities. What his confirmation will mean for the U.S. and global coal industries remains to be seen. 

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Profile of Gina McCarthy

By Geoff Giordano

Contributing Author, *Cornerstone*

The unexpectedly contentious nomination of Gina McCarthy to head the U.S. Environmental Protection Agency (EPA) perhaps mirrors the rocky road facing the coal industry.

When McCarthy, assistant administrator of the EPA's Office of Air and Radiation since 2009, was tapped in March by President Barack Obama to succeed Lisa Jackson, she was generally commended as a consensus-seeking broker of mutually beneficial solutions to improving air quality.¹ She earned praise across the ideological spectrum for her efforts under Republican and Democratic state administrations.

However, when Republican members of the Senate Committee on Environment and Public Works boycotted the advancement of her nomination to the full Senate floor on 9 May, the



Gina McCarthy, Who Once Worked as Top Environmental Official in the U.S. States of Massachusetts and Connecticut and Now Serves as Assistant EPA Administrator

surprising move laid bare the divide over the EPA's recent policy direction and operational processes.² Even when McCarthy's nomination was voted out of committee on 16 May, it was on a 10-8 party-line vote, with ranking minority leader Sen. David Vitter (R-LA) indicating the EPA still had more information to provide regarding some of its practices.³

With the coal industry in the U.S. facing some of its most challenging times, the appointment of "Obama's green quarterback" to take the reins at the EPA raises obvious questions about what impact her leadership would have on the solid-fuels sector.

STAKES ARE HIGH

The U.S. coal industry is in a well-documented predicament. Permits to build new coal-fired energy plants, or to upgrade existing plants to improve efficiency and reduce emissions, are difficult to obtain.⁴ Stricter new EPA regulations and enforcement mean older plants are being allowed to run inefficiently because of the cost of retrofitting them with equipment to limit harmful emissions. Meanwhile, a surge in quantities of cheaper shale natural gas delivered via "fracking" has prompted many plants to switch to that fuel.

"I believe that coal has been and will continue to be a significant source of energy in the United States..."

And yet, "I believe that coal has been and will continue to be a significant source of energy in the United States," McCarthy told senators during her 11 April confirmation hearing, "and I take my job seriously when I'm developing standards for protecting public health to take a look at the economic consequences of those and do my best to provide flexibility in the rules."⁵

However, some, like Sens. John Barrasso (R-WY) and Roger Wicker (R-MS), have taken McCarthy and the EPA to task for decisions that they say have hindered coal-based electricity generation. Certainly, the completed or planned retirement of coal-fired power plants as a result of current federal clean-air requirements stokes suspicion among industry watchdogs.

Unsurprisingly, media reports on McCarthy's career run the gamut from praise to scorn. For example, the Congress Blog of *The Hill* newspaper touted her as a "business-friendly choice" to head the EPA, while a *Forbes* op-ed piece warned she "has a history of misleading Congress".^{6,7}

In a 2011 report, Fox News Insider correspondent James Rosen detailed the impending closure of the coal-fired Kammer Plant in Moundsville, WV, which employs 60 people, as well as two other plants in the state.⁸ Closure of the facilities, owned by American Electric Power, is being directly attributed to EPA rules shaped during McCarthy's tenure as clean-air czar. The retirement of these plants is set for 2014, three years ahead of schedule, due to "some of the most expensive—if not the most expensive—rules ever imposed on the coal-fuel electricity industry," said coal industry executive Steve Miller.

PRAISE FROM BOTH SIDES

While the EPA declined to grant *Cornerstone* an interview with McCarthy, she is generally portrayed by supporters and media accounts as a savvy pragmatist who has served both political parties, is cognizant of the need to balance environmental and economic realities, and displays a strong work ethic in striving to reach common-sense solutions to protect the public and the environment.

"You are one of the best-qualified nominees ever to come before this committee," enthused Environment and Public Works Senate Committee chair Sen. Barbara Boxer (D-CA), in her opening statement at McCarthy's 11 April hearing. "Your combination of experience, intelligence, energy expertise and integrity will make you a most effective EPA administrator. ... At a time when there can be a bitter divide in Washington she has shown a strong bipartisan spirit. ... Because of her common-sense approach to protecting public health, (she) has received support from businesses, health officials, environmental organizations and scientists."

Before the question-and-answer period of the confirmation hearing, as Boxer instructed that letters of support for McCarthy be put into the record, she noted praise for the nominee by William Becker, head of the National Association of Clean Air Agencies: "She's brutally honest, very fair, humorous, and an incredibly hard worker. She's not an ideologue; she's a practitioner." Meanwhile, Sen. Jeff Sessions (R-AL) indicated that "I've heard from some that you'll be a distinct change from your predecessor, and that you're pragmatic and data-driven." There is even a website, Stand With Gina (created by SaveOurEnvironment.org)⁹, that touts McCarthy's record, including the 2011 Mercury and Air Toxic Standards and proposed national limits on carbon pollution from new power plants—moves her detractors say hinder coal's prospects.⁹



U.S. President Barack Obama (C) Nominates (from L-R) Nuclear Physicist Ernest Moniz to Head the Department of Energy, Air Quality Expert Gina McCarthy to Lead the Environmental Protection Agency, and Walmart's Philanthropic Head Sylvia Mathews Burwell to Become Director of the White House Budget Office, in the East Room of the White House in Washington, 4 March 2013. REUTERS/Larry Downing

MCCARTHY'S CAREER

During her confirmation hearing, McCarthy displayed poise and good humor while asserting her intent to pursue the economic and national security benefits of addressing climate change and creating a “clean-energy economy” under the parameters of science and the law. Her attitudes and style have been forged by more than 30 years of public service.^{10,11} Much has been made of her service under five Republican governors—Connecticut’s Jodi Rell, as well as Mitt Romney, Paul Cellucci, (acting governor) Jane Swift, and William Weld in Massachusetts.^{12,13}

McCarthy revels in her Massachusetts upbringing, Boston accent, and having been allowed to yell “Play ball!” before a Red Sox game at Fenway Park.^{14,15} She was born in the Boston neighborhood of Dorchester and remained in Massachusetts until being confirmed for her current EPA post in 2009.¹⁶ She is a Democrat who contributed to President Obama’s 2008 and 2012 campaigns.

After graduating from the University of Massachusetts at Boston in 1976 with a bachelor’s in social anthropology, she earned a dual master’s in environmental health engineering and planning and policy from Tufts University.¹⁷ “When I went to graduate school at Tufts, my intent was to go into the field of public health,” McCarthy recalled during her nomination hearing. “I began in Providence, RI, as my first job out of graduate school, working at community health centers. I was really interested in the delivery of health care at that time, particularly to underserved and poor populations. My mother got ill, and I went home to take care of her.”

McCarthy found a job as a health agent in her hometown of Canton, MA, she recalled. “All of a sudden there was a big controversy about some PCB barrels that had been found in the woods. And I found out that neighbors I had lived near for all my life were very concerned about whether those barrels and that spill was causing them to have cancer in their community. And I got embroiled in a controversy that I was totally unprepared for but worked my way through, and I began to realize a career in public health could be very much be related to the environment.

“I realized very quickly how important it was to people in the community to feel like somebody was protecting them from those challenges. It was in the ‘80s; it was when things were unfolding. Great federal laws were being implemented, and I just got swept into that, and it’s been a great experience ever since.”



McCarthy Testifies Before the Senate Environment and Public Works Committee Hearing on Nomination to be Administrator of the Environmental Protection Agency

After serving in Canton from 1980 to 1984, she joined the board of health in Stoughton and later was appointed by then-Gov. Michael Dukakis to the Hazardous Waste Facility Site Safety Council of Massachusetts in 1985. McCarthy was elevated to executive secretary of the council in 1991 by Weld. She served in various other roles for her home state, eventually becoming Romney’s environmental chief and creating his climate-change plan. In 2004, she was tapped to head Connecticut’s Department of Environmental Protection, a position she held until 2009 before taking her current role in the nation’s capital.¹⁸

Under Romney and Rell, McCarthy was instrumental in reducing carbon and mercury emissions at coal-fired plants. She further targeted greenhouse gas emissions in the wake of the 2007 Supreme Court decision *Massachusetts v. EPA*.

“As a top environmental official in Massachusetts and Connecticut, she helped design programs to expand energy efficiency and promote renewable energy,” President Obama said on 4 March in announcing McCarthy as his choice to lead the EPA. “As assistant EPA administrator, Gina’s focused on practical, cost-effective ways to keep our air clean and our economy growing. She’s earned a reputation as a straight shooter. She welcomes different points of views.”

DIRECTION ON COAL AND CLEAN AIR

Several of McCarthy's dealings with industry and regulating greenhouse gases provide insight into her collaborative style and decision-making process. For example, during McCarthy's confirmation hearing, Sen. Tom Udall (D-NM) lauded the nominee for her leadership and guidance in brokering a deal that will result in the closure of two of four coal-fired units at the San Juan Generating Station by the end of 2017. The compromise calls for the two retired units to be replaced by a natural gas unit, while the two remaining units are retrofitted with pollution controls.¹⁹

It is just such efforts that Republican senators voiced concern about during the hearing. "With regard to coal, I agree with Senator Barasso: Excessive rules from EPA affecting coal-fired power plants pose a serious threat to America's economic competitiveness," Wicker noted. "Because Mississippi has diverse fuels and power generation technology options, including coal, our state can offer electric rates below national average and attract more job-creating investment. The president said in 2008, 'We can develop clean-coal technology.' EPA needs to help make good on that promise. EPA's regulatory assault on coal does not diminish the influence of foreign energy producers or bring down prices for families and businesses."

In his remarks prior to the committee vote on 16 May, Vitter indicated he felt that "it's very clear that this EPA has had a pretty dismal transparency record," citing the use of alias email accounts as well as "unresponsiveness in terms of requests for the underlying research data behind crucial EPA regulations, including those Gina McCarthy has been in charge of" and "completely inadequate—in some cases laughable—economic analysis that don't begin to account for full costs or benefits" as well as "often secret sue-and-settle agreements behind closed doors which advance an environmental left agenda without proper openness, transparency and input."

Rancor flared on the morning of the 9 May business session when GOP senators sent a letter to Boxer expressing dissatisfaction with McCarthy's answers to the more than 1000 questions submitted to her after her 11 April hearing.²⁰ During comments throughout the remainder of that session, a noticeably upset Boxer urged Republicans to "get out of the fringe lane ... I don't know who they want to be the head of the EPA—maybe the head of some polluting oil company or coal company. That'd make them happy."

But away from Capitol Hill, in the trenches of policy creation, McCarthy earns praise—sometimes begrudging—in executing her duties. None other than John McManus, vice president of

"...I take my job seriously when I'm developing standards for protecting public health to take a look at the economic consequences of those and do my best to provide flexibility in the rules."

environmental services for AEP, recalled his negotiations with McCarthy in regards to cutting soot emissions. "My sense is that Gina is listening (and) has an open mind," McManus said. "She wants to hear the concerns of the regulated sector."⁹ When AEP, which in 2011 planned to cut 600 jobs across the U.S.,²¹ indicated concern over a particularly restrictive rule, McCarthy compromised to alleviate some of AEP's compliance costs. "Did she do all the things we thought would be best?" McManus said. "No, but we do see that she's trying to do things that would achieve regulatory balance." 

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For Some Coal Producers Power Plant Regulations Offer a Silver Lining

There is no question that coal producers in the Appalachian Basin in the eastern U.S. are feeling the effects of shale gas production and environmental regulations for their main end users—coal-fired power plants. However, there is another source of pressure on central Appalachian producers—their counterparts in the Midwest. The Illinois Basin, which is mainly in southern Illinois, Indiana, and western Kentucky, increased coal output by about 10% last year. By 2015 it is expected that coal production from the

Illinois Basin will actually exceed that from Appalachia, which boasted nearly double the production capacity as recently as 2010. So what's fueling this switch? Sulfur dioxide scrubbers are being added to coal-fired power plants as a result of recently enacted regulations. With the addition of these new state-of-the-art scrubbers, higher sulfur coals, such as those produced in the Illinois Basin, can be burned without the sulfur dioxide being released into the air.

Healthy Business

By Nikki Fisher

Coal Stewardship Manager, Anglo American Thermal Coal

Healthcare is a sound investment for any company and is fundamental to being a responsible employer. It is not only about caring for employees, but also about improving business performance. Health and well-being are paramount to productivity and safety in the workplace.

Anglo American, and in particular their Thermal Coal business unit, has proven this by supporting their South African employees in the battle against HIV and AIDS. To any large employer, a debilitating, sexually transmitted disease that could affect more than 25–30% of the adult population presents a significant risk to the business. This is particularly true in a developing country, where most workers are male and often living away from their families with money in their pockets.

A GLOBAL PROBLEM

In the early 1980s, there was a perception that the HIV epidemic was largely restricted to white, gay men, mostly in the northern hemisphere. This was soon to change.



Investing in Life—Aids Peer Educators Take the Messages about HIV/AIDS into Their Communities

In 1986, Anglo American recognized the very high risk of an HIV/AIDS epidemic in South Africa, given the migrant labor system in place at most mines. This prompted the company to launch two initiatives: an education and awareness program aimed at its entire workforce; and the provision of over US\$5 million in funding to HIV and AIDS research. In the same year, roughly 18,000 mine workers were tested for HIV, and only four were HIV positive. This was a remarkably low 0.02% of workers compared to the situation today, when it is estimated that about 17% (13,000) of workers at Anglo American's southern African operations are HIV positive.¹

"Healthcare is a sound investment for any company and is fundamental to being a responsible employer. It is not only about caring for employees, but also about improving business performance."

HIV/AIDS is a devastating global problem. In 2011, 1.7 million people died of AIDS-related diseases and an estimated 34.2 million people were living with HIV, 68% of which live in sub-Saharan Africa. There were also approximately 2.5 million new infections in 2011, including an estimated 330,000 children. Anglo American has operations in regions, such as sub-Saharan Africa, where the HIV/AIDS impact to human life and to business cannot be ignored; in response, Anglo American has developed a strategic approach to address the epidemic.

STRATEGIC APPROACH TO EMPLOYEE HEALTH

The Three Zeros

Our targets for the HIV/AIDS program are zero new infections, zero people dying from AIDS-related illness, and zero babies being born HIV positive. UNAIDS, the Joint United Nations Program on HIV/AIDS, has now adopted these same targets. Anglo American believes these can be achieved through zero tolerance for discrimination, zero stigma, and zero gender inequality.

People-Focused

The fundamental tenet of human rights is that every person has a basic right to life. In South Africa, the constitution further states: “Everyone has the right to have access to healthcare services, including reproductive healthcare.” This forms the foundation for the Anglo American HIV/AIDS policy. The policy strives to eliminate stigma and gender inequalities, and prevent the further spread of HIV infections. It commits to ensuring that all affected employees and their dependents have access to the care, support, and treatment they may need. Anglo American believes that the health and well-being of our people and our host communities is the greatest challenge for 21st century mining.

Early Diagnosis, Early Treatment

Early diagnosis and early access to treatment lie at the core of all our HIV/AIDS programs. The entry point for the Anglo American HIV/AIDS response is therefore the central need for everyone to know their status. In 2002, Anglo American announced that it would provide free testing and treatment to all its workers. The uptake on the Voluntary Counselling and Testing (VCT) program was fairly slow, with less than 10% of employees being tested in 2003. However, today, over 90% of employees check their status on an annual basis.

Medical research has shown that if an HIV-positive person adheres to an effective anti-retroviral therapy (ART) regimen, the risk of transmitting the virus to their uninfected partner can be reduced by 96%.² However, HIV/AIDS cannot be effectively managed when only one person receives care for a disease that affects the entire family. As such, in 2008, the HIV/AIDS program was extended to include employees’ dependents. This allows the HIV-positive staff to live healthy, normal lives.

The success of the program is measured by the rate of conversions from HIV negative to positive, which is dubbed the “safe-sex indicator”. In 2005, it was 2.1 for every 100 staff at Anglo American’s Thermal Coal division; so far in 2013, it has fallen to 0.7. In 2009, Anglo American Thermal Coal won the Global Business Coalition award for its pioneering workplace program on tackling HIV and AIDS in South Africa.

It is often said that prevention is the best cure, so, in addition to testing and treatment, Anglo American has a three-pillar prevention program to slow down and ultimately try to stop new infections. Education and awareness, condom distribution, and early diagnosis and treatment are the three components of the prevention program. Extensive campaigns

“The fundamental tenet of human rights is that every person has a basic right to life. In South Africa, the constitution further states: ‘Everyone has the right to have access to healthcare services, including reproductive healthcare.’”

are run annually to educate staff and reduce the stigma associated with the disease.

THE TUBERCULOSIS LINK

There is reason for new concern with the rising incidence of tuberculosis (TB)—a disease that is inextricably linked to the incidence of HIV due to reduced immunity which allows opportunistic TB infection. In South Africa, rates of TB/HIV co-infection and TB incidence are the highest in the world, and the escalating TB epidemic could give more cause for concern



Testing for HIV Using Oraquick is Simple and Effective

than the HIV/AIDS epidemic. The number of new TB cases is another good indicator of how well HIV infection is being managed. Anglo American's TB-control program is based on similar principles to the HIV/AIDS program: early detection and early treatment.

THE HEALTH SOURCE

The Anglo American health program continues to evolve as we learn more about the problem and the best way to tackle it. For example, the ability to capture and manage data using information systems has proved critical to Anglo American's thermal coal business. The business introduced a digital health record program in 2007, disproving initial claims that it would be impossible to gather large volumes of confidential health-related information. After conducting more than 100,000 tests, there has never been a single formal challenge for breach of confidentiality or stigmatization.

This has been achieved using an electronic health record system, called the Health Source, which enables real-time, confidential tracking of individuals' health information. The Health Source fulfils all the requirements for an integrated health record system, ensuring that the health record of every miner is available wherever they go in their career within the company, wherever they receive care, and, when necessary, the progression of illness is tracked. At a glance, health professionals can see when an individual became HIV positive, when treatment began, their current viral load and CD4 count (a white blood cell that indicates the stage of HIV or AIDS). The system also prompts actions, for example, flagging a patient who has not had a CD4 count check.

In 2013, Anglo American received a commendation in the GBCHealth Business Action on Health Awards in the Technology for Health category for the Health Source. Thermal Coal regional medical manager Dr. Jan Pienaar, who developed the system with in-house IT specialists Julia Denton and Thia Grobler, was recently invited to speak about the system and its benefits at two medical conferences in Holland. The first was hosted by the Netherlands Society of Occupational Medicine and the second by the KNCV Tuberculosis Foundation, which is committed to reducing TB in around 40 countries globally.

A HEALTHY APPROACH TO BUSINESS

Although the overall impact of HIV/AIDS on the company, including the cost of the ART program, is equivalent to 3.4% of payroll, without treatment the company would be in a far worse position. Employee health is central to business. Since the inception of the HIV/AIDS program when ART was first made available to employees, Anglo American:

- Reduced absenteeism by 1.9 days per employee per month, saving R702 (US\$96) per month
- Saved an average R264 (US\$87) per employee per month through effective ART and the resulting reduction in healthcare expenses
- Saved an average R264 (US\$36) per patient per month by reducing staff turnover

This monthly saving of R1603 (US\$219) per individual compares favorably with the R922 (US\$126) per individual treatment cost. The benefits of the program far outweigh the costs.

The money Anglo American spends on its HIV/AIDS response gives a very positive return on investment and also contributes to improved employee well-being, trust, loyalty, and safety. 🧑🏻

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North American Shale Gas Production: A Bright Dawn for the Global Energy Trade or a Gloomy Monday?

By Les Deman

President, Les Deman Energy Consulting Co.

The terms “game changer” and “disruptive technology” are often reserved for Silicon Valley or the pharmaceutical industry; however, they are increasingly being applied to the development of North American shale gas and shale oil resources. At the start of the millennium, the U.S. was facing a growing gap between gas demand and production. In a government- and industry-sponsored study in 2003, the National Petroleum Council concluded that North American producing areas will only provide 75% of long-term needs and that new, large-scale resources such as LNG and Arctic gas would be necessary to meet demand.¹ Today, some studies predict that North America will soon be a net exporter of natural gas and that oil shale development has the potential to reduce imports to zero within 20 years. In less than a decade the petroleum outlook in North America changed from a mature and declining industry to a vibrant and fast-growing economic segment of the economy.



An Aerial Photo of the Dominion Liquefied Natural Gas Facility in Cove Point, Md.

If the optimism about North American shale resources is borne out, it will have a profound effect on world energy markets. A high degree of success in exploiting gas and oil shales would be contagious, increasing activity levels across the globe. Larger supplies of natural gas and oil would depress the price for all fuels. Moreover, lower energy prices would encourage consumption and raise economic growth. There would be changes in the geopolitical and economic balance among exporting and importing nations as oil/gas purchase options increase and as nations become more energy self-sufficient. In the near term it would be wise for world energy markets to prepare for North America becoming a global LNG exporter.

“If the optimism about North American shale resources is borne out, it will have a profound effect on world energy markets.”

THE U.S. EXPERIENCE

How and when these shale fuels will be developed outside North America remains uncertain; still it might be useful to provide some background on the U.S. shale gas experience, in particular its market disruptions and cyclicity. Throughout its 100-plus-year history the petroleum industry focused on conventional natural gas production, which accounted for about two-thirds of U.S. production 10 years ago.^A Declining natural gas production after 2000 prompted global petroleum companies and domestic gas utilities to propose 23 new LNG import terminals by 2003.¹ Those proposals were abandoned a few years later when it became apparent that technical innovations in fracturing shale and horizontal drilling would result in a resurgence in U.S. natural gas production. As Figure 1 shows, by 2012 U.S. gas production was one-third higher than the 2005 trough and shale gas accounted for 37% of the total energy production.

Adding so much supply in a relatively short period transformed the North American market from one that was in a shortage

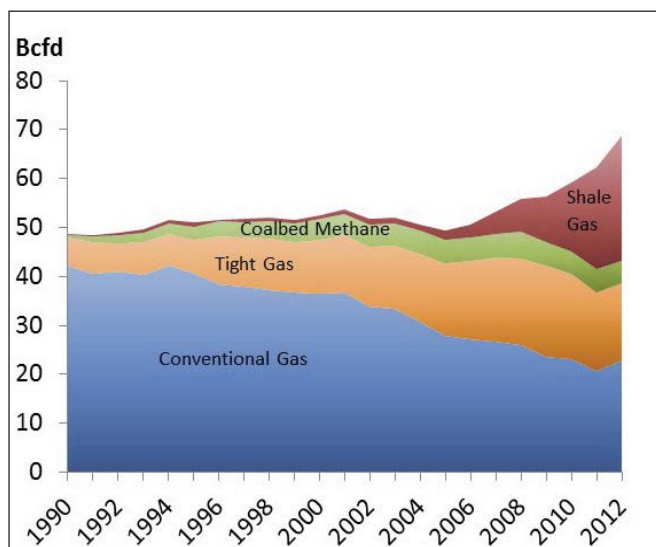


FIGURE 1. Recent U.S. Natural Gas Production History. Source: U.S. Energy Information Administration. Coalbed methane production in 2012 was estimated and conventional gas includes tight gas. (Note: Bcfd = billion cubic feet per day)

condition to one in surplus. Since the North America gas market is basically a closed system, with little ability to engage in international trading, this surplus sent natural gas prices plummeting. In 2005 the spot price (\$2012) of Henry Hub natural gas, which is the primary North America benchmark, peaked at over \$10.00 per million Btu (MMBtu), but by 2012 it fell to \$2.75 per MMBtu. In contrast, internationally traded natural gas was priced at a sizeable premium to the Henry Hub, particularly after 2009 (see Figure 2). Since quantity demanded always equals quantity supplied, the market was forced to find unique ways to maximize demand and constrain supply.

Finding markets to absorb large volumes of natural gas proved daunting because this period included the largest economic decline since the Great Depression. Total U.S. energy consumption fell in both 2008 and 2009, impacted in part by business closures and downsizing. Over these same two years natural gas consumption also showed a net decline (up slightly in 2008 but down in 2009) due primarily to falling use in the industrial sector. The industrial sector saw a rebound in 2010 as economic growth resumed, with natural gas use rising about 2.5 Bcfd (+15%) between 2009 and 2012. Residential and commercial consumers have not generated any demand growth over this period due to more efficient appliances, milder winters, and a tepid new housing market. The only contestable market left for natural gas was power generation.

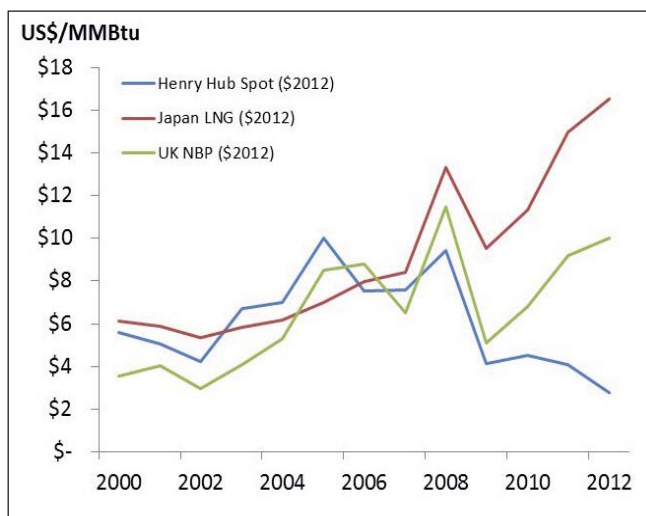


FIGURE 2. Key International Natural Gas Prices

On a gross basis, the electric power sector increased gas use by about 8.9 Bcfd between 2005 and 2012 (+55%). With net generation roughly flat over this period (see Figure 3) most of the gain in natural gas consumption was at the expense of coal. This gain in gas share accelerated in 2008, when in a period of seven months (September 2008 to April 2009), the market bid down nominal Henry Hub spot gas prices from an \$8-handle to a \$3-handle. Various estimates have gas-for-coal displacement climbing from near zero in 2008 to roughly 2.5 Bcfd in 2009. By 2012, which saw the Henry Hub spot price fall to \$2.00 per MMBtu in April, coal-to-gas switching

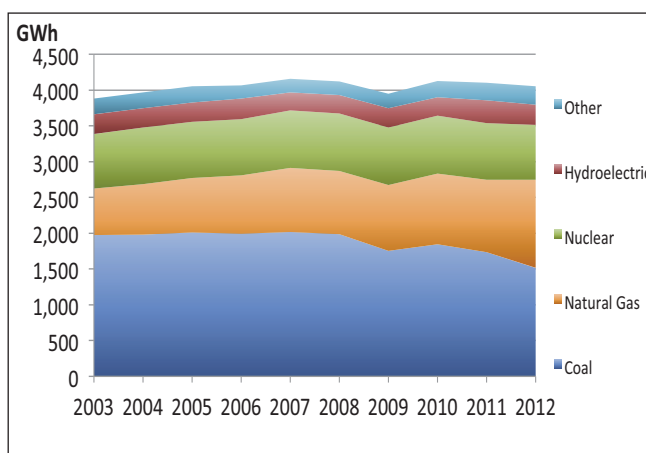


FIGURE 3. U.S. Net Electricity Generation by Source. Source: U.S. Energy Information Administration²

boosted electric power generation demand for natural gas by nearly 7.0 Bcfd. Of course, coal's share of the electric generation market plummeted from 50% in 2005 to 37% in 2012. Surplus U.S. coal supplies sent exports soaring over 150% over this seven-year period, with Europe the main recipient (up 250%).

With so much new domestic natural gas, U.S. imports saw a rapid decline. Net natural gas imports to the U.S. totaled 9.9 Bcfd in 2004, mainly from Canada; but by 2012, volumes declined to 4.1 Bcfd, a 58% plunge. Moreover, low U.S. prices increased the demand for exports to Mexico, which rose by 103% over the same period.

To the market's surprise, shale gas production kept growing despite natural prices widely acknowledged to be below exploration and production costs. History has shown that for commodities like natural gas—those that involve large amounts of capital to purchase leases, develop fields, and construct necessary infrastructure—it is often difficult to quickly ramp activities up or down. Low natural gas prices impacted gas drilling activity, with recent reports showing fewer than 400 rigs drilling for gas versus the modern day peak of 1606 rigs in August 2008.

Now, in early 2013, some data suggest that natural gas production growth has flattened and that declining drilling levels may now be sufficient to balance supply and demand. With Henry Hub natural gas futures generally seeing prices

above \$4.00 per MMBtu for the first time in roughly 18 months, the market appears to be giving credence to a tighter supply-demand balance in the months ahead.

What many analysts in the U.S. have garnered from this four-year cycle is that, in the near term, the market clearing sector on the demand side is electric power generation, with natural gas prices targeting gas-for-coal switching economics. On the supply side, the U.S. was able to ratchet down natural gas imports from Canada, but matching domestic gas production to demand was more difficult and storage levels set record highs. Moreover, there is every reason to believe that North America has the capacity to increase shale gas production significantly over the next two decades, raising the possibility that it might become a major LNG exporter.

INTERNATIONAL IMPLICATIONS: LESSONS AND OPPORTUNITIES

Over the past two decades a host of studies have projected rapid growth in the global natural gas trade.⁷⁻⁹ On the demand side, the driver for this growth is an increased emphasis on cleaner burning fuels, particularly in the electric power and industrial sectors as a replacement for coal and oil. Supply-side drivers include international capital to exploit remote gas resources in the Middle East, Russia, and Australia and commensurate investment to deliver the gas to consuming areas via LNG or pipeline. Consumers were excited about prospects for obtaining an attractive fuel at a discount to oil,

"If the optimists hold sway, not only will the price of these fuels decline, there will also be many buyers to choose from."

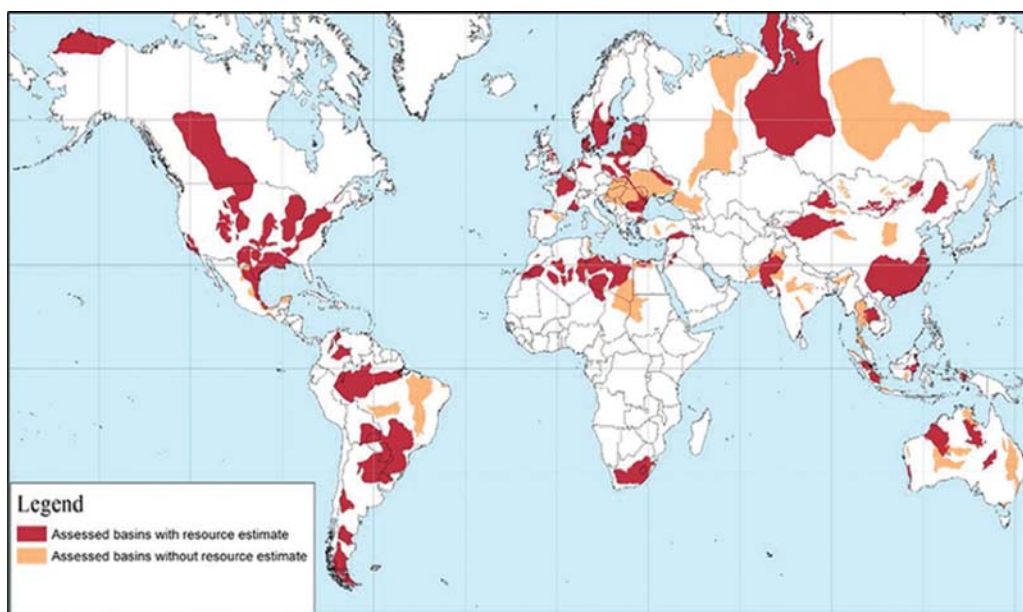


FIGURE 4. EIA Assessment of Potential World Shale Gas Sources.¹¹

while exporters were looking to sell gas at an oil-equivalent basis. There were even discussions about forming a gas cartel similar to OPEC to enhance pricing power. With the rapid development of North American shale gas and optimism on international shale gas prospects (see Figure 4), this paradigm has changed drastically.

Efforts are underway to determine the viability of shale gas developments outside North America, with recent activity in China, Poland, the UK, Argentina, and elsewhere. Thus far there are few reports of sustained activity levels, so great uncertainty remains about the scope and timing of exploiting this potentially large resource. Nonetheless, the promise of this bonanza is emboldening natural gas importers to negotiate for lower prices and better terms.⁹ It may well be that the catalyst in moving the international gas trade toward a free market will be the onset of North American LNG exports.

Today, there are only three approved LNG export terminals in North America: the Kenai Alaska Terminal, operating since 1969, the Sabine Pass Louisiana Terminal, and the Freeport Texas Terminal. The latter two LNG terminals were initially constructed as Gulf Coast import facilities and will not be capable of exporting gas until 2016 or 2017. However, there are applications to export over 28 Bcfd of LNG in the U.S. and proposals to build 22 export terminals, 17 in the U.S. and five in Canada.⁸ Many of these proposals are placeholders for companies that would like to profit if the U.S. reduces natural gas export constraints. These constraints include industry groups that are lobbying the U.S. Congress to keep cheap and plentiful natural gas in North America for gas-intensive

manufacturing, such as petrochemicals. Environmental groups are against new terminals to prevent coastal damage and because of public safety concerns. Alternately, energy producers are lobbying Congress to accelerate LNG export permits.

In addition to U.S. politics, North American LNG exports are dependent on a multitude of variables, including: future global economic growth; environmental regulations on fossil fuel use in all nations; shale gas production costs and fracking regulations; world oil and natural gas prices; competitive actions of other natural gas exporters; technological progress on carbon capture and storage, growth in renewable fuels; and energy efficiency gains. Looking at a few scenarios can provide perspective on the impact that North American shale gas can make.

Two recent studies provide a number of U.S. LNG export scenarios (Figure 5). In the 2013 U.S. Annual Energy Outlook (AEO), the Reference Case shows new LNG exports beginning at 0.6 Bcfd in 2016 and gradually rising to 4.5 Bcfd in 2040.¹⁰ In a more optimistic scenario, High Resource and Low/No Net Imports, LNG exports rise to 10.6 Bcfd in 2040. Another recent report by NERA Economic Consulting to the U.S. Department of Energy showed that LNG exports in 2035 could range from 3.8 Bcfd to 15.8 Bcfd.¹² Canada could easily add 3.0–5.0 Bcfd of LNG exports to the equation.

Nations importing these incremental volumes of LNG could use the re-gasified product to displace coal, oil, or other more carbon-intensive fuels. The energy content of 1.0 Bcfd of LNG is the equivalent of about 180,000 barrels of oil per day or roughly 14 million metric tons of coal on an annual basis. Using optimistic North American LNG export assumptions result in the displacement of over 5% of estimated annual world oil and coal use in the 2030–2040 timeframe and a much larger share of world trade in these fuels.^{6,13} Unit prices and producer revenues would be lower for oil and coal exporters, and upheavals could be precipitated in exporting nations that depend on these proceeds for income supplements, for subsidies to influential groups, and for related programs.

Adding to the potential for disruption is the likelihood of a rapidly growing supply of liquids from the shale revolution. For gas-prone shales, the liquids come in the form of natural gas liquids (NGLs), which should grow by 144% in the U.S. between 2010 and 2030 according to the AEO's High Resource Case. In this same case, production growth from oil shale would make the U.S. self-sufficient by 2040. There is no reason to believe that other regions with potential shale resources would not also see a surge in liquids production.

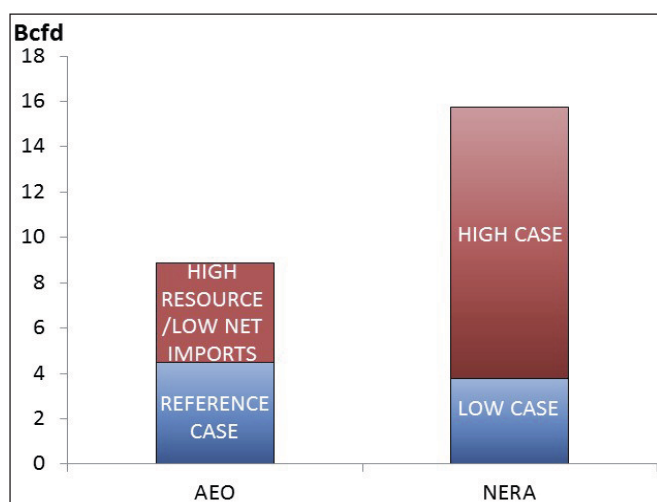


FIGURE 5. Scenarios for U.S. LNG Exports in 2035.

Sources: U.S. Energy Information Administration and NERA^{10,12}

HEDGE YOUR BETS

It is difficult for most businesses to foresee the long-term effects of game-changing or disruptive technologies, much less take advantage of them. While it remains to be seen whether developments in producing natural gas and oil from shales qualify for such a designation, the reemergence of natural gas and oil growth in the U.S. is impressive. However, we have less than a decade of history to judge whether this is an ad hoc event. We still do not know if this trend will continue and if so, for how long? Nor do we know whether the North American experience is applicable to other regions. While it may take a few more years to answer these questions, savvy businessmen and governments that have livelihoods tied to alternate fuels such as coal and conventional petroleum should hedge their bets.

On the consuming side, I would be reluctant to enter into long-term and fixed price contracts for any fuel—coal, oil, nuclear, pipeline natural gas, or LNG. If the optimists hold sway, not only will the price of these fuels decline, there will also be many sellers to choose from. Producers of coal and other fuels can try to lock in long-term, fixed price contracts, perhaps with take-or-pay clauses. This might prove advantageous even if the terms are more lenient than in current agreements. Getting the buyer to invest in the supply chain might be another way to protect a producer via investments in production, transportation, export/import terminals, and end-use facilities.

Then again, some new technology could make natural gas and oil shale developments uneconomic. Low-cost carbon capture and storage could reinvigorate coal. Battery technology and low-cost solar power could make central electric power stations obsolete. It is not a question of whether a better mousetrap will come along, it is just a matter of when. My advice is to invest in a portfolio of energy-producing and consuming technologies and be in a position to take advantage of the next “game changer”. 🐭

NOTES

- A. Note that shale gas and oil is a subset of “unconventional” petroleum fuels. Unconventional oil and gas typically includes production from tight formations, coalbed methane, shales, kerogen, hydrates, etc.
- B. For an updated list see: fossil.energy.gov/programs/gasregulation/reports/summary_lng_applications.pdf

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Relationship between U.S. and International Coal Pricing

By Emily Medine
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THE WORLD IS GETTING FLATTER

The increased size of the global coal market combined with the number and diversity of supply sources has caused global coal prices to be increasingly interrelated and to have spill-over impacts on domestic coal pricing in countries producing coal. In the U.S., the direct relationship has increased as a result of the relative weakness of the U.S. dollar, the widespread use of U.S. dollar-based indices to price coal, and a supply of U.S. coal available for export. The relationship between U.S. coal and international coal pricing is likely to increase further with growth in global coal trade driven by increased demand, particularly from Asia, an increased reliance on coal exports to maintain/expand production levels, and the growth in export infrastructure, particularly into Pacific markets.



St. James Stevedoring is an Example of a Coal Port in the Gulf of Mexico that Employs Highly-Efficient Midstream Loading of Coal onto Ocean Going Vessels

“While the price of coal was historically stable compared to the major fluctuations observed in oil and natural gas prices, volatility has increased in recent years due to market dynamics.”

GLOBAL COAL MARKETS AND TRADING

In 2011, world coal production exceeded 7.6 billion tonnes.^A Most coal is characterized by use as either thermal (i.e., steam), for use in boilers and kilns, or metallurgical, for use as a feedstock in the production of steel, although some coal can fit either application. Such coals are referred to as cross-over coals. Although most coal is consumed in the country in which it is produced, both types of coal are traded in the international market. In 2011, the International Energy Agency (IEA) estimated world coal trade to be over 1.1 billion tonnes, comprised of 861 million tonnes of steam coal and 276 million tonnes of metallurgical coal.¹ The seaborne market makes up about 90% of global trade with about 10% traded over land.

To figure out where the coal trade market is going it is helpful to look at where it has been. The seaborne steam coal market has increased fourfold since 1990. While Europe and Japan accounted for the bulk of demand until 2000, since then the growth has primarily been in Asia. On the supply side, Indonesia has become the dominant supplier of steam coal while Australia, South Africa, and Colombia are significant as well. In the last two years, exports from the U.S. increased significantly, due in large part to surpluses caused by the increase in production and usage of shale gas. Figure 1 shows the sources for supply and demand of the seaborne steam coal trade.

Coal sold into the export market is generally sold at the loadport or delivered to a destination port. In addition, coal

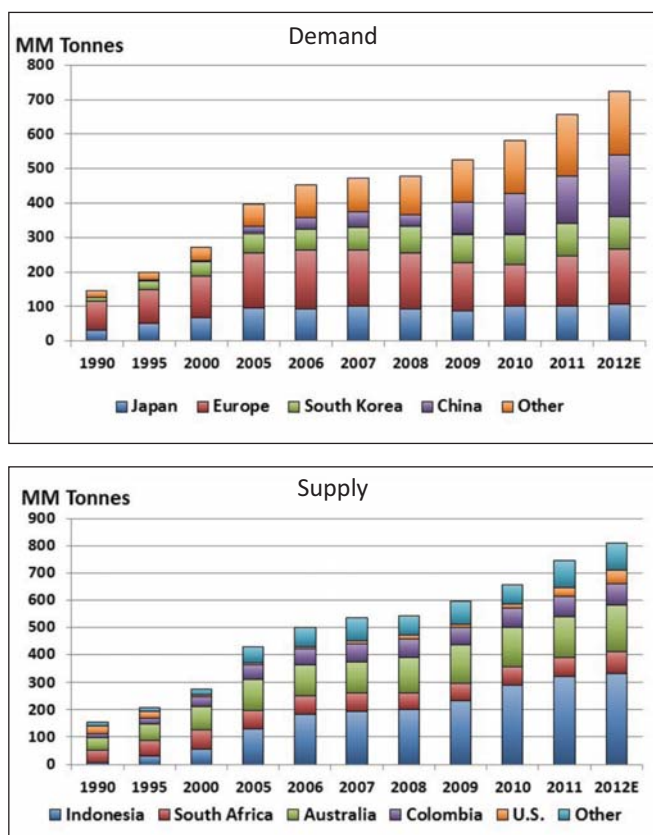


FIGURE 1. Seaborne Steam Coal Trade Demand and Supply.
Source: SSY²

sold into the global market can be sold on either a fixed price or an indexed basis. A number of coal indices have been developed over the years to allow for both physical and financial trading. As all global seaborne coal trade is U.S. dollar-denominated, all of the indexes are in U.S. dollars. The indexes tend to vary by geographic area with certain indexes dominant in the Atlantic market and other indexes dominant in the Pacific market, although indexes do cross over between markets (e.g., coal in the Pacific market could be sold on an API4^B basis). While some coal is actually traded at the indexes, coal is more often traded at a premium or discount to the indexes depending upon market conditions. Forward pricing is common in the coal trade.

Parties which sell or purchase coals tied to liquid indexes can convert all or a portion of their positions from floating to fixed through financial instruments offered by banks as well as many producers/traders themselves. As each party can use its own hedging strategies, it is not unusual for there to be a divergence between what a producer/trader is realizing in the sale of the coal and what a buyer/consumer is paying for it.

INTERRELATIONSHIP OF U.S. COAL PRICING WITH INTERNATIONAL PRICES

While the price of coal was historically stable compared to the major fluctuations observed in oil and natural gas prices, volatility has increased in recent years due to market dynamics. A number of factors have increased the relationship between U.S. and international coal prices; each factor is discussed below.

Value of U.S. Dollar

With global coal pricing U.S. dollar-denominated *and* the U.S. representing a small share of total exports, the relative strength of the U.S. dollar has been very relevant to the establishment of global coal price levels. The relationship of most significance has been between the U.S. dollar and the Australian dollar as Australia is the largest exporter of metallurgical coal and until 2011 the largest exporter (in tonnes) overall. Indonesia surpassed Australia in 2005 as the largest exporter (in tonnes) of steam coal.

The U.S. dollar has significantly weakened vis-à-vis the Australian dollar over the last decade except for a relatively short period during the global financial crisis in 2008/2009. The significance of this weakening can be seen in a simple example. For an Australian coal producer to realize the *same* value for its coal in Australian dollars, the price in 2013 would have to be 77% higher than it was in 2003 just to capture the difference in currency. This increase does not take into account general inflation or real changes in commodity prices, such as fuel oil. Obviously, the higher the global price of coal, the more U.S. coal producers can realize for their product.

The significance of the exchange rate is best seen through an example. In the 1990s, a number of parties, including Japanese trading companies, agreed to construct a coal terminal near Los Angeles, CA. The terminal, referred to as LAXT, was designed to handle 10 million tons of coal expected to originate in the Rockies coal supply region, i.e., Utah and Colorado. The commitment to build the terminal was made when the U.S. dollar was relatively weak. As shown in Figure 2, the U.S. dollar strengthened significantly after the commitment was made, changing the relative economics of Rockies coal into the global market. Not surprisingly, relatively few tons moved through the terminal and the decision was made to close (and decommission) the terminal about five years after it started operating. Ironically, with the decreased strength of the U.S. dollar almost since its closing, this terminal would be in great demand if it were operational today.

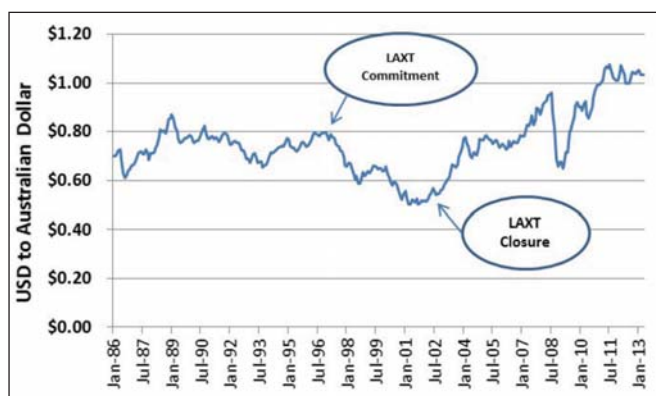


FIGURE 2. The Relative Value of the U.S. Dollar to the Australian Dollar

Limited Sources of Metallurgical Coal

Metallurgical coal is a subset of the global coal market, currently accounting for about 25% of global coal trade. Two factors distinguish the metallurgical coal trade from the steam coal trade: first, and most significant, the fewer number of sources of metallurgical coal; second, and not unrelated, the higher value of this product.

Three countries (Australia, the U.S., and Canada) account for about 85% of metallurgical coal trade; see Figure 3 for details. For more than a decade, Australia has accounted for over 50%, and in recent years over 60%, of the volume. As a result of the limited supply, a disruption in one country can affect not only the market for metallurgical coal but the coal market overall. As discussed above, this is because some coals moving in the steam coal market can cross over into the metallurgical market when metallurgical coal supply is tight. As a result, the steam coal market firms as additional coal is needed to fill the vacuum created by the cross-over coals.

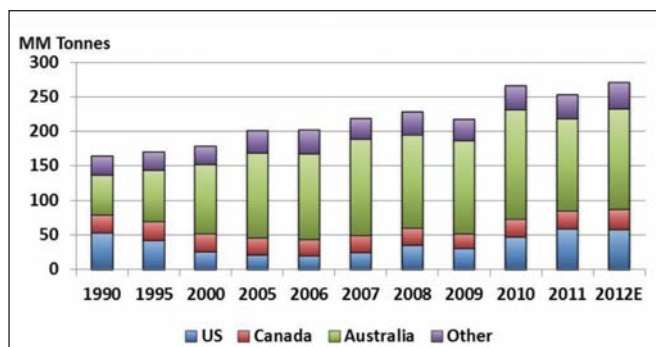


FIGURE 3. Global Metallurgical Coal Supply. Source: SSY²

The best example of the relationship of metallurgical coal supply to steam coal pricing occurred in late 2010/early 2011 as a result of heavy rains and extensive flooding in Queensland, Australia, the primary source of metallurgical coals in Australia. The significance of this event can be seen above in the reduced metallurgical coal exports from Australia in 2011. It can also be seen in the increase in the benchmark price of metallurgical coal in the first quarter of 2011, see Figure 4. Due to the ability of some coals to cross over and the huge premium for metallurgical coal, the global price of steam coal also rose in the first quarter of 2011 as did the price of U.S. steam coal.

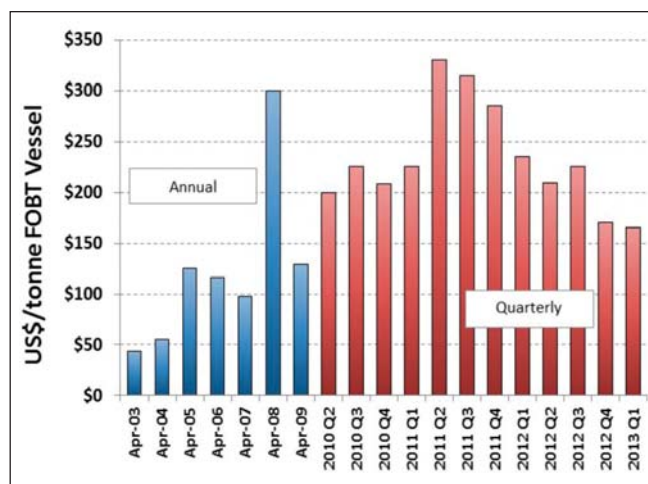


FIGURE 4. International Metallurgical Coal Benchmark Prices

More recently, it was the U.S. coals which affected the global market. In 2011 and 2012, domestic demand for U.S. coals declined for several reasons, the most significant of which were the increased supply of shale gas and the very mild winter of 2011/2012 that created a significant natural gas supply overhang. The excess supply had no place else to go in the short term except the utility market,^c and natural gas prices fell to the levels necessary to allow combined cycle-fired natural gas plants to dispatch ahead of coal plants. The net effect was a steep decline in domestic utility demand, thereby creating a supply overhang of coal. In order to manage the excess coal supply, producers, consumers, and traders looked to the export market. The large increase in exports, as shown in Figure 5, combined with distress pricing actually caused the global market price to decline. The historical price table shows that the decline in Appalachian coal prices preceded the decline in the Atlantic market price.

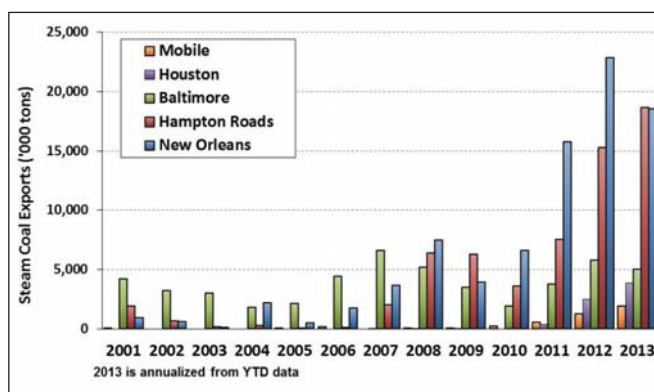


FIGURE 5. Exports of U.S. Steam Coal from the East Coast and Gulf

NETBACK PRICING

The increase globalization of coal supply has resulted in export coal prices being set as netbacks from key market hubs. In the Atlantic market, the key market hub has historically been northwest Europe, or Amsterdam, Rotterdam, and Antwerp (ARA). Based upon the ARA price and prevailing shipping rates from each loadport to ARA, an FOB (free on board) loadport price can be determined for each coal source by subtracting the freight from the ARA price. Using “estimated” rail and port charges for U.S. coals, FOB mine prices can be compared to the netback price to determine both the relative competitiveness of the U.S. coals and the price they could hope to realize. When the netback price is higher than the market price, the coal is competitive.

At prices extant in early Q2 2013, U.S. coals are largely uncompetitive into Europe given the prevailing market prices. In fact, the only coal competitive to Europe at this particular time is Colombian coal which has a netback above the prevailing market price. While the market does continually rebalance, the point is pricing in the global market is based upon netback pricing, which further integrates all of the various supply regions.

WHAT WOULD IT TAKE TO INCREASE PRICE INTERCONNECTEDNESS?

The current limitations on price interconnectedness with U.S. coals fall into two categories: Atlantic market prices and west coast export terminal capacity. As shown above, pricing outside of the U.S. actually only affects eastern U.S. coal prices when U.S. coals can trade near the global value. At current global prices, most U.S. coals are not competitive and new trades will

“For an Australian coal producer to realize the same value for its coal in Australian dollars, the price in 2013 would have to be 77% higher than it was in 2003 just to capture the difference in currency.”

only occur at a discount to market prices. This situation is likely temporary, and U.S. competitiveness will improve with modest firming of the market. Expanding west coast export terminal capacity is required to realize the sizable growth in exports of western coal into the Pacific market, as current western U.S. coal exports are limited to small terminals on the west coast, Canadian terminals, and movements through the Great Lakes or the U.S. Gulf, none of which are very efficient. Although a number of new terminals and terminal expansions have been announced, any significant expansions are being challenged and are likely years away. Until such expansions occur, the interconnectedness of western U.S. coal prices to the global market is likely to be muted. 🔄

NOTES

- Global coal production and trade statistics are notoriously inconsistent between sources. Sources are cited for the statistics reported in this article.
- API4 is the index for South African coal FOB vessel in Richards Bay Terminal, South Africa.
- The U.S. had significantly overbuilt combined cycle natural gas capacity which allowed the switching to occur.

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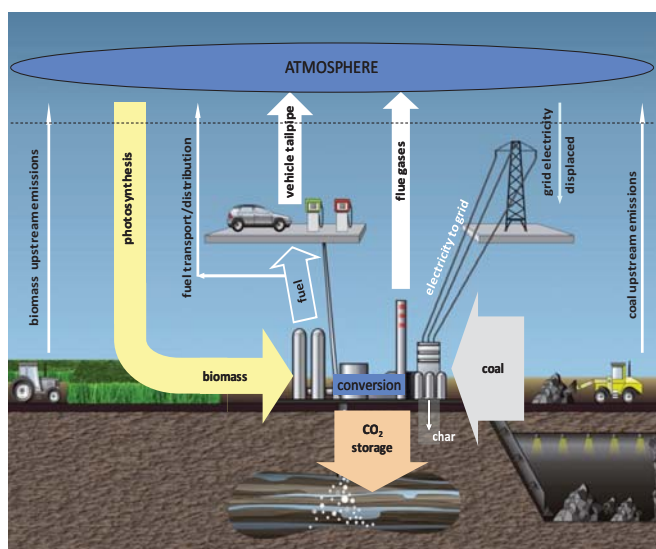
Toward Market Launch of Coal/Biomass Coproduction Technologies with CCS

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ARTICLE BACKGROUND

This is the second installment of a two-part article prepared for *Cornerstone* discussing how coal/biomass co-processing technologies for making synthetic fuels and electricity with carbon capture and storage (CCS) can enable continuing major roles for coal in a carbon-constrained world. The first installment¹ presented a long-term vision highlighting the merits of the strategy. This second installment focuses on establishing the key technologies in the market in the near term (next 10–15 years). The acronyms used in this article are defined in Table 1.



Carbon Flows for Conversion of Coal and Biomass into Synthetic Liquid Fuels and Electricity with CCS

The “cradle-to-grave” GHG emission rate for a system like that shown depends on the biomass input percentage. For the CBTL-OTA-5%-CCS system (see Table 2B and Figure 1) for which sustainably grown biomass accounts for 5% of input feedstocks, the net fuel-cycle-wide GHG emissions associated with production and consumption of liquid fuels and electricity is half of the GHG emission rate for the conventional fossil fuels displaced.

INTRODUCTION

The first installment of this article showed that (a) the profitable production of low-carbon transportation fuels (hitherto an elusive goal) is feasible under a carbon mitigation policy by coprocessing some non-food biomass with coal in systems that involve pre-combustion capture of CO₂ and its storage underground; (b) for specified carbon footprint and biomass input rate, it is more profitable to generate electricity as a major coproduct than to make only liquid fuels; and (c) in an era of high oil prices, such coproduction systems are more profitable than coal electricity-only plants that have the same carbon footprint.¹

However, before the coal/biomass coproduction with CCS concept can be regarded as a major option for coal’s future in a carbon-constrained world, the technology must be demonstrated at commercial scale and costs must be reduced to levels at which the technologies can compete without subsidy.

“Before the coal/biomass coproduction with CCS concept can be regarded as a major option for coal’s future in a carbon-constrained world, the technology must be demonstrated at commercial scale and costs must be reduced...”

The strategic importance of these objectives was recognized by the National Coal Council (NCC) in its 2012 report to U.S. Department of Energy Secretary Steven Chu.² Two major recommendations from the report were that the U.S. coal industry and the Energy Secretary work together to find ways whereby: (a) early-mover coal-based CO₂ capture projects linked to CO₂ enhanced oil recovery (CO₂ EOR) could be financed and

TABLE 1. Acronym Definitions

Acronym	Definition
CTL	Coal to Fischer-Tropsch liquid synthetic fuels (diesel and gasoline)
CBTL	Coal/biomass to Fischer-Tropsch liquid synthetic fuels
OT	Fischer-Tropsch liquids plant design for which synthesis gas is passed only "once through" the synthesis reactor and involving "mild" CO ₂ capture; unconverted gas is burned to make electricity as a major coproduct in a combined cycle power plant
OTA	Fischer-Tropsch liquid plant design for which synthesis gas is passed only "once through" the synthesis reactor and involving "aggressive" CO ₂ capture; unconverted gas is burned to make electricity as a major coproduct in a combined cycle power plant
CO ₂ EOR	Enhanced oil recovery by means of CO ₂ injection
Sup PC	Coal to electricity via new supercritical pulverized coal power plant
IGCC	Coal to electricity via integrated gasifier combined cycle power plant
NGCC	Natural gas to electricity via combined cycle power plant
-V	A plant that vents all CO ₂
-CCS	A plant that captures CO ₂ for storage in a geological formation
GHGI	Greenhouse gas emissions index = (fuel-cycle-wide GHG emissions for production + consumption of a plant's energy products)/(GHG emissions for the fossil fuel products displaced); see footnote c to Table 2A.
IRRE	Internal rate of return on equity

built to enable technology cost reductions via experience (i.e., learning by doing) and (b) a coal/biomass coproduction plant with captured CO₂ used for EOR be financed, built, and demonstrated at commercial scale. This article suggests how both of these NCC report recommendations might be implemented in the near term in the absence of a carbon mitigation policy.

CO₂ EOR FOR EARLY-MOVER CCS PROJECTS

Storing CO₂ via CO₂ EOR is an important option for helping launch CO₂ capture technologies in the market in the absence of a price on GHG emissions, because the CO₂ provider is paid for captured CO₂. CO₂ EOR is a well-established technology in the U.S., where there are 6600 km of CO₂ pipelines serving 127 EOR projects; in 2012, CO₂ EOR provided 6% of U.S. crude oil production: 280,000 barrels/day (bbls/d) (13.8 million tonnes/year). Most CO₂ for EOR comes from natural sources; U.S. crude oil production via EOR could be greatly expanded by supplementing natural CO₂ with anthropogenic CO₂, the largest potential supplies of which are coal energy systems from which CO₂ is captured.

Drawing in part on assessments of U.S. CO₂ EOR prospects (e.g., U.S. DOE NETL³), the National Coal Council reached the judgment that it is feasible to increase U.S. crude oil production via CO₂ EOR by 2035 to 3.6 million bbls/d (177

million tonnes/year) using captured CO₂ from coal energy systems, while storing annually over 400 million tonnes of anthropogenic CO₂ in mature oil fields from which the extra crude is extracted.² This is enough to support a large number of early-mover CCS projects, each of which will typically provide 1–5 million tonnes of CO₂ annually.

The NCC report found that in the absence of a price on GHG emissions, once CO₂ capture technologies are commercially established: (a) coal power plants retrofitted with CO₂ capture equipment could provide CO₂ profitably for EOR if sited near CO₂ EOR opportunities, and (b) new synthetic fuels plants and plants coproducing electricity and synthetic fuels, even if remote from CO₂ EOR opportunities, are likely to be profitable in CO₂ EOR applications if an adequate CO₂ pipeline infrastructure is in place.

That is the good news. The bad news from this report is that first-of-a-kind (FOAK) and subsequent early-mover projects will not be able to provide CO₂ for EOR applications profitably without subsidy in the absence of a price on GHG emissions, because such projects will be very costly. Early-mover projects are typically more costly than commercially established [Nth-of-a-kind (NOAK)] projects for various reasons. An engineering, procurement, and construction (EPC) firm building a novel plant may add spare capacity for some components to promote integrated system reliability. For pieces of equipment with which there is

little experience, an EPC firm will estimate costs with higher-than-normal process contingency factors (which are added to reflect costs that cannot be fully accounted for). Moreover, for novel plant configurations, *project* contingency factors will tend to be higher than normal even if all components are commercially established. And for such novel plant configurations, equipment layout may be suboptimal, requiring more investment for linking processes.

THE HIGH-COST CHALLENGE POSED BY EARLY-MOVER CCS PROJECTS

In the absence of carbon mitigation policy, the subsidies required for early-mover CCS project are huge (e.g., the subsidy required for a single FOAK CCS project is likely to be comparable to the total applied energy R&D budget of the U.S. Department of Energy), so that supporting, via conventional government funding mechanisms, a series of such projects in efforts to “buy-down” technology costs through experience (learning by doing) is beyond the reach of most, if not all, governments. These high early-mover subsidy costs have slowed progress in establishing CCS as a major carbon-mitigation option. For perspective, in 2009 the International Energy Agency (IEA) set out a road map⁴ calling for building 100 CCS projects by 2020, together capturing ~150 million tonnes of CO₂ annually as needed, to be on track for realizing ~50% reduction in global CO₂ emissions for energy by mid-century.⁵ At present, however, the prospects are that, at best, 20 projects will be completed by 2020.⁶

PROPOSED CO₂ CAPTURE TECHNOLOGY COST BUYDOWN STRATEGY

Because the CO₂ EOR opportunity alone cannot provide adequate incentives for launching coal/biomass coproduction and other capture technologies in the market, going forward with CCS technologies in the absence of a strong carbon mitigation policy requires additional incentives that are affordable even by fiscally constrained governments.

In the U.S., sponsors of the National Enhanced Oil Recovery Initiative (NEORI) have proposed a competitively bid tax credit to help “buy down” the cost from FOAK to NOAK levels for plants that capture CO₂ and make it available for CO₂ EOR applications.⁷ The NEORI sponsors propose that this tax credit be financed via new federal corporate income tax revenue streams from EOR-produced oil that would replace otherwise imported crude oil. The basic idea is that, as a result of learning by doing, the required tax credits would decline with experience to levels below the levels of these new federal tax revenue streams, so that this strategy would provide *new*

revenues to the federal government that could help “buy down the federal deficit” at the same time that the proposed subsidy would help “buy down the cost” of CO₂ capture technologies.

Here a variant of the NEORI buy-down proposal developed by the author⁸ is summarized. It involves providing subsidies in the form of competitively bid grants (rather than tax credits, so that the subsidy magnitude is not limited by tax liability) that are proportional to the amount of captured CO₂ made available for EOR. The grants would be financed to the extent feasible with *new* federal revenues arising from these projects in the forms of corporate income taxes from synfuels production (for CO₂ capture technologies that provide synthetic fuels), corporate income taxes from crude oil production via CO₂ EOR, and royalties from crude oil produced via CO₂ EOR on federal lands. Revenues needed to finance the subsidies in excess of what can be provided by these new federal revenue streams would be paid for out of general federal funds (GFF).

IRRE SCREENING ANALYSIS

The first step in the CO₂ capture cost buydown analysis is to identify the capture technologies that, after buydown, are likely to be profitable in CO₂ EOR applications without subsidy or a price on GHG emissions. To this end, internal rate of return on equity (IRRE) analyses were carried out for four electricity systems and two systems coproducing electricity and Fischer–Tropsch liquid synthetic fuels (diesel and gasoline). The candidate electricity-only systems (see Table 2A) are (a) a new supercritical coal plant with post-combustion (amine scrubber) CO₂ capture (Sup PC-CCS); (b) a new coal integrated gasification combined cycle plant with pre-combustion capture (IGCC-CCS); (c) a subcritical coal plant retrofitted with an amine scrubber (PC-CCS retrofit); and (d) a natural gas combined cycle plant with an amine scrubber (NGCC-CCS). The candidate coproduction options (see Table 2B) make electricity as a major coproduct (accounting for 28–32% of total energy output) of manufacturing Fischer–Tropsch liquid transportation fuels. One option is CTL-OT-CCS, a coal-only system with mild CO₂ capture option for which GHGI = 0.70. The other is CBTL-OTA-5%-CCS, a coal/biomass system with “aggressive” CO₂ capture that coprocesses enough biomass (5% on an energy basis) to realize a 50% reduction in GHG emissions (GHGI = 0.50). Figure 1 shows how a 50% reduction in GHG emissions can be realized for transportation fuels with only 5% biomass.

The coproduction options considered as power generators would satisfy the U.S. Environmental Protection Agency’s proposed New Source Performance Standard for CO₂ emissions from new power plants (the EPA has proposed a limit of 1000 lbs CO₂/gross MWh_e for new plants): Allocating all CO₂ emissions from the coproduction plant to gross power, the emission rates would be

TABLE 2A. Candidate Power-Only Options for Technology Cost Buydown

Technology Options	Sup PC-CCS ^a	IGCC-CCS ^a	PC-CCS Retrofit ^b	NGCC-CCS ^a
Net electric output capacity, MW _e	550	543	398	474
Conversion efficiency (HHV), %	28.4	32.6	24.7	42.8
GHGI ^c	0.2	0.17	0.23	0.2
CO ₂ to stack, lb CO ₂ /MWh _e (gross)	87	152	203	319
% of feedstock C captured as CO ₂	90	88	90	90
CO ₂ storage rate, 10 ⁶ tonnes/year	4.1	3.4	3.5	1.4
Capital for NOAK plant, \$10 ⁹	2.1	1.8	0.84	0.71

^a Based on US DOE NETL.⁹^b Based on NCC.²^c GHGI (the greenhouse gas emissions index) is defined as the ratio of the “cradle-to-grave” GHG emissions for the system to the emissions for the conventional fossil energy displaced. The latter are assumed to be electricity from new supercritical coal plants venting CO₂ (Sup PC-V) and the equivalent of crude oil-derived products.

TABLE 2B. Candidate Coproduction Options for Technology Cost Buydown

Technology Options	CTL-OT-CCS	CBTL-OTA-5%-CCS
Net electric output capacity, MW _e (% of energy output)	389 (31.9)	317 (27.6)
FTL output capacity, bbls/day	13,100	
Conversion efficiency (HHV), %	46.1	43.6
Biomass in feedstock, %, HHV basis	0	5.1
Biomass input, 10 ⁶ tonnes/year	0	0.21
GHGI	0.7	0.5
CO ₂ to stack, lb CO ₂ /MWh _e (gross)	609	265
% of feedstock C captured as CO ₂	52	64
CO ₂ storage rate, 10 ⁶ tonnes/year	3.5	4.4
Capital for NOAK plant, \$10 ⁹	2.4	2.6

*Based on Liu et al.¹⁰

609 lb/MWh_e for CTL-OT-CCS and 265 lb/MWh_e for CBTL-OTA-5%-CCS (see Table 2B).

The IRRE analysis is carried out as a function of the crude oil price, assuming the average Permian Basin CO₂ price during 2008–2010 [in \$/t = 0.444 × (crude oil price, in \$/bbl); see Wehner¹¹] and a CO₂ transport cost of \$10/t (nearby CO₂ EOR opportunity).

The results of the NOAK IRRE screening analysis are presented in Figure 2, which shows IRRE values as a function of crude

oil price when the GHG emissions price is \$0/t CO_{2e}. This analysis shows that the coproduction options and pulverized coal plants with CCS retrofit (PC-CCS retrofit) should be considered as serious candidates for technology cost buydown because an IRRE rate of 10%/year (a minimally acceptable level of profitability for many investors) is realizable for these options at plausible future crude oil prices. But, notably, none of the new power-only plants with CCS clear this IRRE “hurdle rate” at any of the crude oil prices considered, so these options are not considered further here.

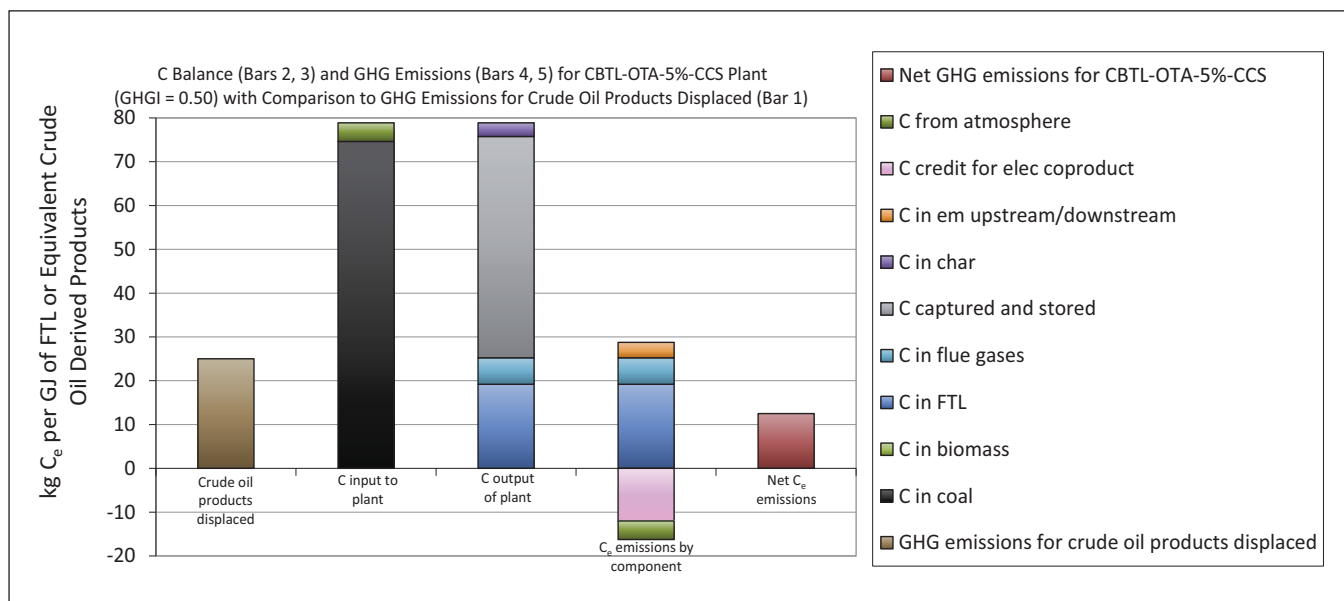


FIGURE 1. Carbon Balances and GHG Emissions for Fischer-Tropsch Liquid Fuels From CBTL-OTA-5%-CCS (GHGI = 0.50)

- 1st bar shows fuel-cycle-wide GHG emission rate for crude oil-derived diesel and gasoline displaced
- 2nd and 3rd bars show carbon balance for plant (carbon output = carbon input)
- 4th bar shows fuel-cycle-wide GHG emissions by component (+tive and –tive elements)
- 5th bar shows net fuel-cycle-wide GHG emissions for Fischer-Tropsch liquid fuels
- Credit for emissions from electricity $\{ @ 0.50 * [841 \text{ kg CO}_2\text{e}/\text{MWh}_e \text{ (rate for new Sup PC-V)}] \} = (0.106 \text{ MWh}_e/\text{GJ FTL}) * (420 \text{ kg CO}_2\text{e}/\text{MWh}_e) = 44.0 \text{ kg CO}_2\text{e} \text{ or } 12.0 \text{ kg C}_e \text{ per GJ of Fischer–Tropsch liquid fuels.}$

TECHNOLOGY COST BUYDOWN ANALYSIS

The technology cost buydown analysis aims to estimate the subsidies required for early-mover projects and provide a perspective on the benefits as well as the costs of providing subsidies for the screened technologies. For this exercise, FOAK costs are estimated by “back-casting” from NOAK cost estimates in Tables 2A and 2B. Key assumptions in addition to those for the IRRE screening analysis are:

- FOAK costs [for capital and operation and maintenance (O&M)] are $2.0 \times$ NOAK costs, which is consistent with Duke Energy’s experience with its Edwardsport IGCC-V plant being built in Indiana;
- The learning rate for capital and O&M costs is the same as the historical learning rate for SO₂ scrubbers¹², some 11% for each cumulative doubling of output—which means that those costs for the second plant are 11% less than for the first, those costs for the fourth plant are 11% less than for the second, those costs for the eighth plant are 11% less than those for the 4th, etc.;

- The subsidy provided over the 20-year economic life of the plant is sufficient to reduce the levelized cost of electricity to that for a natural gas combined cycle power plant that vents CO₂;
- Subsidies are financed to the extent feasible from new federal revenue streams from new domestic liquid fuel production; the shortfall is provided by general federal funds (GFF); and
- The crude oil price is \$90/bbl.

Figure 3 shows, for the three screened options, the required subsidy versus the number of the plants built. [The required subsidies decline at different rates because the fraction of the levelized cost of electricity amenable to learning by doing (capital + O&M costs) varies from technology to technology.] For CTL-OT-CCS, the required subsidy is reduced through learning by doing to zero after only 13 plants have been built. The zero subsidy point is reached for the 25th plant with CBTL-OTA-5%-CCS and for the 133rd plant with PC-CCS retrofit. Figure 3 also shows that for all three plants the GFF contribution to the subsidy is zero for the third plant.

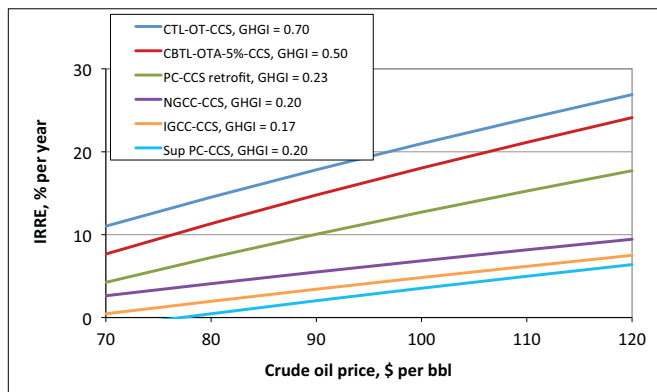


FIGURE 2. IRRE vs. Crude Oil for NOAK Plants Listed in Tables 2A and 2B (for Plants Selling CO₂ into EOR Markets in the Absence of a Price on GHG Emissions)

Table 3 presents total subsidy requirements together with net new government tax/royalty revenues associated with the liquid fuels production arising from deployment of these plants. The subsidies for the very first plants are huge (\$1.6 to \$3.1 billion), and the average subsidies for the first 13 plants are also large (~\$1 billion per plant). Nevertheless, these technology cost buydown investments are profitable for the government. By the time the fourth to sixth plant is built, the government is generating net new federal revenues arising from taxes and royalties associated with new domestic liquid fuels production. The average net new federal revenues per plant for the first 13 plants amount to \$0.95 billion, \$0.60 billion, and \$0.33 billion for CTL-OT-CCS, CBTL-OTA-5%-CCS, and PC-CCS retrofit, respectively.

Subsidy requirements would be less at higher crude oil prices. For example, at \$115/bbl: (a) the first CTL-OT-CCS plant would require a \$2.1 billion subsidy, (b) only the first five plants would require subsidies (at an average rate of \$0.82 billion

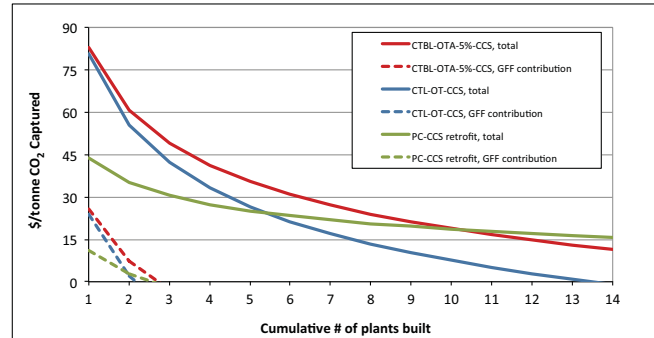


FIGURE 3. Total Subsidy and GFF Contribution for Technology Cost Buydown for \$90/bbl Crude Oil in the Absence of a Price on GHG Emissions

per plant), (c) net new government revenues would average \$1.8 billion per plant for these first five plants, and (d) net new government revenues would be positive (\$0.77 billion) for the very first plant.

TECHNOLOGY READINESS

The buydown analysis suggests favorable economic prospects for launching, in the near term, coproduction technologies coprocessing a modest amount of biomass with coal and using captured CO₂ for EOR. In addition, all technological components required for a FOAK plant are ready to be demonstrated at commercial scale—especially if a demonstration project were to involve cogasification of a low-rank coal and biomass (the CBTL-OTA-5%-CCS system described in Table 2B is for bituminous coal and biomass gasified in separate gasifiers), as illustrated by recent Southern Company experience.

Southern Company (an energy company serving the Southeast United States through its subsidiaries) has developed (with long-term U.S. DOE support) the transport gasifier that is well

TABLE 3. Buydown Subsidies and Net New Federal Revenues for Technologies Selected for Buydown

Energy Conversion System	Subsidy, \$10 ⁹		Plant for Which Cumulative New Government Revenues Net of Subsidies Become Positive	Net New Federal Revenues, Average Per Plant for 1 st 13 Plants, \$10 ⁹
	1 st Plant	Average Per Plant for 1 st 13 Plants		
PC-CCS retrofit	1.6	0.86	5 th	0.33
CTL-OT-CCS	3	0.92	4 th	0.95
CBTL-OTA-5%-CCS	3.1	1.26	6 th	0.6

suited for cogasification of biomass with low-rank coals (e.g., lignite or subbituminous coal). Already this gasifier is being deployed in a 580 MW_e lignite-fired U.S. DOE-supported commercial-scale demonstration project (Kemper County, Mississippi, IGCC-CCS project) that will use captured CO₂ for enhanced oil recovery (EOR). The National Carbon Capture Center at the Power Systems Development Facility in Wilsonville, Alabama, has carried out tests on the co-gasification of up to 30% biomass with low-rank coals utilizing pure oxygen as the oxidant (to provide syngas quality necessary for synthetic fuels manufacture) at a test-scale version of the transport gasifier, and such percentages were found to pose no adverse impact to gasification system operations.¹³

Southern also has experience with biomass supply logistics at supply levels higher than are needed for a demonstration project—evolving in large part from experience with its 100 MW_e waste wood-fired Nacogdoches power plant in Texas, which consumes annually about 1 million short tons of wood [as-received (wet) basis]. Assuming that the as-received wood has a 50% moisture content, this implies that the Nacogdoches plant already consumes dry biomass at a rate that is about 2.3 times the rate for the CBTL-OTA-5%-CCS system described in Table 2B.

CONCLUSION

Success with the proposed course of action for early-mover coal/biomass coprocessing systems that coproduce electricity and liquid fuels could (a) help get the global CCS enterprise back on track;^{6,14} (b) undermine the conventional wisdom that addressing climate change and seeking domestic energy independence often represent contradictory goals;¹⁵ and (c) provide a technological platform that would enable the coal industry to thrive in a carbon-constrained world.¹ 🤖

ACKNOWLEDGMENTS

The author is grateful for fruitful discussions with the late Jim Katzer in developing several of the concepts presented here. For financial support, the author thanks The Edgerton Foundation and the BP-supported Carbon Mitigation Initiative at Princeton University.

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Water Resource Protection Technology for Coal Mining in Western China

By Gu Dazhao

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WATER SHORTAGE: A CONSTRAINT TO COAL MINING IN WESTERN CHINA

The western provinces and autonomous regions such as Shanxi, Shaanxi, Inner Mongolia, Gansu, and Ningxia, are bestowed with abundant resources. Such resources are characterized by large, integrated coalfields with optimal geological conditions, the most concentrated deposits, and the highest quality coal in China. After years of development, this area has become a coal production base featuring fully-mechanized modern mining techniques. As a major coal supply region, western China sets the standard for China's coal industry and plays an important role in the country's coal supply network. In 2012, production from the five provinces and



A River Winds through Inner Mongolia in a Region Where It is Vitally Important to Protect Water Resources

"Western China is China's major coal producing area. The aridity and the shortage of water are characteristics caused by natural climatic conditions in this area."

autonomous regions reached 2.59 billion tonnes, accounting for 71% of the overall coal production in China.

China is constantly challenged by severe droughts and water shortages. With the world's fourth largest fresh water reserve, the country has 2800 billion m³ of freshwater, accounting for 6% of the global total. The water resource per capita, however, is merely 2200 m³, only one quarter of the global average. Western China is exceptionally dry with scarce and unevenly distributed water, by location and season. For instance, the northern part of Shaanxi Province is an inland area with high evaporation and little rainfall. The local per capita water resource is merely 927 m³.

It is unavoidable that large-scale and intensive coal mining operations in this area will have negative impact on local water resources. The movement and state of surface and underground water can be affected by coal mine tunnels and depleted gobs (waste rock from coal mining). Examples of potential effects on water include changing the underground water cycle and that can lead to dried-up streams, groundwater recession, and drastic decrease. Together with the enormous amount of mine water discharge, all these problems pose a severe threat to the local ecosystem. Water conservation, therefore, is recognized as the key to sustainable development in this region. However, conventional water conservation technologies are not easily employed in this region due to unique climatic characteristics and the geological formation of coal deposits. It is therefore highly necessary to develop and study new technologies tailored for mining operations in this region.¹⁻³

WATER CONSERVATION DEVELOPMENT BY THE SHENHUA GROUP

Shenhua Group is the world's largest coal production company; in 2012, the raw coal production was 460 million tonnes. The Shenhua Group's coal resources are mainly located in western China. Since 2003, the Shenhua Group has launched a number of technical projects on the coordinated exploitation of resources and environment. These research projects have been focused on water conservation and utilization technologies. Based on Coordinated Development Technology of the Resources and Environment in Super-large Mine Groups, Conservation and Utilization Technology of Water Resources in Mining of Ten Million Tonnes Mine Group, Underground Water and Surface Ecological Conservation Technology of Shendong Mine Area and demonstration projects, etc., underground water migration directions have been revealed, some technological problems of distributed underground reservoirs of coal mines, such as water migration pathways in the reservoir, construction of coal pillar dam and artificial dam, water scheduling among reservoirs, water treatment technology, and safety monitoring, have been solved. A technology system of distributed underground reservoirs of coal mines has been established.^{4,5}

DISTRIBUTED UNDERGROUND RESERVOIRS OF COAL MINES

Large quantities of mine water must be drained to ensure safety during coal mining. However, there are many disadvantages to draining mine water: It results in extreme waste of the water; in addition, mine water drained to the ground surface results in pollution. Moreover, because it is arid in western China, evaporation occurs rapidly and most drained water will evaporate before it can be effectively utilized.

To conserve and utilize water resources effectively, water resource protection and utilization technology must be developed. However, the location of the coal seam is shallow in western China, and coal mining will most certainly impact aquifers and result in the loss of groundwater. Therefore, continued innovation is essential to improve beyond the traditional approaches to water preservation during coal mining. If the purification and storage of the mine water under the colliery without drainage can be accomplished, it will lead to the realization of water-preserving mining in this area.

As discussed in previous sections, the key challenge related to water preservation while mining in western China is finding

means not to drain the mine water. One concept is to use the goafs (i.e., the part of the mine from which the coal is extracted) formed by underground mining to store the mine water. If this storage is supplemented by engineering measures, the stored water can be utilized by connecting the water to the surface by drilling holes. The connections among multiple goafs of water storage through artificial pipelines result in an interconnected underground water system, which is distributed throughout coal mine underground reservoirs.^{6,7}

CONSTRUCTION OF DISTRIBUTED UNDERGROUND RESERVOIRS OF COAL MINES

The coal mine underground reservoirs technology system is composed of design technology, construction technology, and operation technology.⁸

Design Technology

The design stage primarily includes assessment of three areas: migration patterns of groundwater, site selection of groundwater reservoirs, and capacity design of groundwater reservoirs. Through geophysical exploration, geological drilling, and by assessing similar material in the lab experimentally and with 3D numerical simulations, the migration patterns of groundwater can be assessed to provide the basis for the construction of groundwater reservoirs. The key characteristics to be explored include the hydrogeology, aquifer, aquiclude (barrier to the movement of water), water-filling conditions of mines, ponding of neighboring goafs, and water gushing in mines. By researching the properties of the stratum in the goafs and the permeability of the roof and floor strata, the construction sites for the groundwater reservoirs can be determined by combining the production technologies and mining parameters as well as the configuration of the working face. With the studies on the spatial dimensions of goafs, stratum conditions, roof caving, and density of the loose body, the optimal reservoir capacity can be determined.

Construction Technology

The engineering and construction of the groundwater reservoirs consists of damming and seepage prevention. The damming forms the water storage goafs by preserving the coal pillars and purposefully sequencing mining arrangements at the working face. Seepage prevention includes conducting geological exploration on the palisades and coal walls in the goafs, assessing their permeability, and carrying out seepage-proofing engineering at important locations.



Distributed Underground Reservoirs Have Been Built at the Daliuta Coal Mine in the Shendong Coal Mining Area

Operation Technology

The operation of the groundwater reservoirs includes the reservoir monitoring, coordination, and control of reservoirs. Therein, groundwater reservoir monitoring mainly includes water quality monitoring, security, and protection technology. The water quality sensors can measure the water quality in real time. The security and protection of the groundwater reservoirs is designed to prevent a dam break by monitoring the water level and dam seepage.

The distributed underground reservoirs of coal mines are connected by artificial tunnels or pipelines, which can regulate the water volume in different reservoirs and maximize the utilization of the reservoir capacity.

CASE STUDY

The Daliuta coal mine in the Shendong mining area is located in Shenmu county of Shaanxi Province; this coalfield is approximately 120 km². Located on the southeast edge of the Mu Us Desert, it is a drought-stricken area with an annual rainfall of 441.2 mm and total evaporation potential of 2111.2 mm. Given the shallow depth and thick coal seam, there is a severe impact to the groundwater due to artificial drainage caused by mining and water loss due to mining-related fractures in aquifers. The conventional approach to mitigate impacts to groundwater is to pump all underground

mine water to the surface for treatment, keeping a small fraction to meet the demands of the mining operations while discharging the rest. This approach not only wastes the precious water resources, but also is a source of pollution to the surface environment. Before introduction of distributed underground reservoirs, the normal water influx at Daliuta was approximately 450 m³/h, with only 180 m³/h recycled, meaning a large amount of water was not being utilized effectively.

A distributed underground reservoir demonstration project was developed at the Daliuta mine, which resulted in zero water discharge, as illustrated in Figure 1. The 2⁻² coal seam is divided into 6 panels. Except for panel 1 which is still being used for coal production, all the rest of the panels have been fully recovered, providing sufficient space for underground water reservoirs. Based on analysis of factors such as the engineering geology of the gobs, strength and permeability of the coal wall, and water demand on the ground, appropriate gobs were selected to be water storage areas. No. 1, No. 2, and No. 3 underground reservoirs have been built; these reservoirs are connected by tunnels or pipes to form the distributed underground reservoirs. The No. 4 underground reservoir is under construction in panel 3 of the 5⁻² coal seam. Mine water from the 5⁻² coal seam, treated by small underground water treatment equipment, can be pumped to the 2⁻² seam via drainage pipes. The water will then flow through injection holes into storage areas and then will be

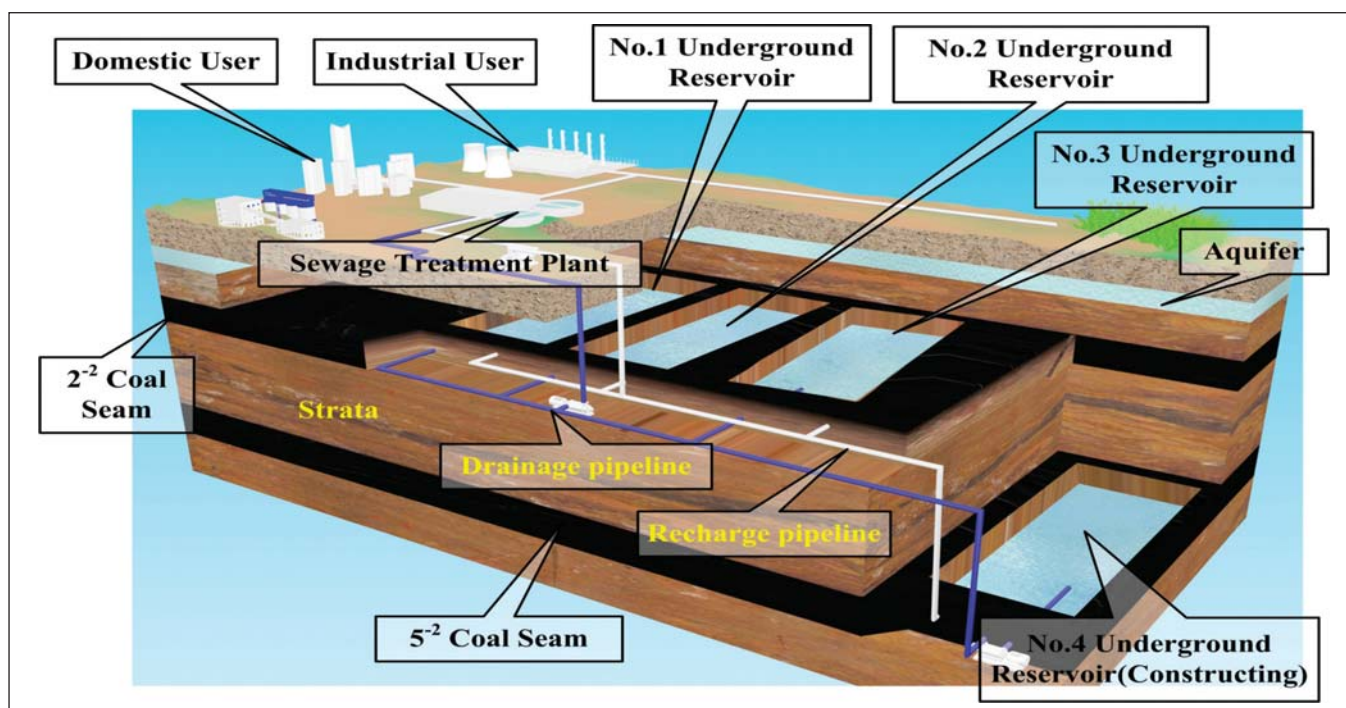


FIGURE 1. Distribution of Groundwater Reservoirs in Daliuta Coal Mines

purified by gangues (i.e., non-valuable material left behind) in the gobs. The pumping stations then pump the purified mine water to grade level for further treatment before being used for industrial, irrigation, and/or domestic purposes. The remaining water is returned to the gobs for storage through inverted wells.

Built in 2010, the distributed underground reservoirs in Daliuta now have a storage capacity of 2.35 million m³. While ensuring near-zero discharge, the project has also resulted in efficient and integrated utilization of mine water.

The technology of underground storage, treatment, and utilization of mine water has been applied to other mines in the Shendong mining area such as Bulianta, Shangwan, and Wulanmulun, which can be considered an important step taken towards “water preservation” during mining.

DISTRIBUTED UNDERGROUND RESERVOIRS OF COAL MINES AS A STRATEGIC MEASURE TO PROTECT WATER RESOURCES

Western China is China's major coal producing area. The aridity and the shortage of water are characteristics caused by natural climatic conditions in this area. Large-scale, intensive coal mining has damaged groundwater and resulted in drainage of

large amounts of mine water, which wastes water and has polluted the surface ecology. In addition, a large amount of water has evaporated without being sufficiently utilized because of the high rate of surface evaporation. The process of coal mining can inevitably destroy the overlying strata and forms water-flowing fissures. The traditional water preservation strategy emphasizes “blocking” and “cutting”, that is, trying to block up or cut off the migration of the groundwater during mining by means of water source protection, mining with filling, impermeable section protection, or repair. However, it is exceedingly difficult from both a technical and engineering perspective, and often satisfactory results are not achieved. Therefore, a change from the traditional water-preservation mining policy and adoption of the “draining” strategy is urgently needed. This policy should be based on research and an understanding of the influence of mining on groundwater, transfer of the mine water produced to a safe underground storage space (so as to realize the underground storage and allocation of the mine water), utilization of the water according to the local needs, and achieving the target of no drainage of mine water.

To achieve these goals, this article has proposed construction of distributed coal mine underground reservoirs to reduce and prevent the drainage of mine water, realize the underground storage and purification and filtration of water, optimize the

“The key challenge related to water preservation while mining in western China is finding means not to drain the mine water.”

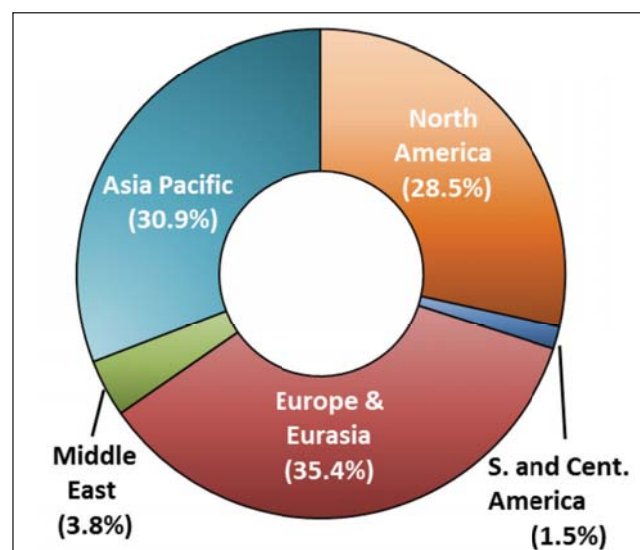
storage of water resources through recharging water pipelines, and realize the effective utilization of water resources by taking advantage of the pumping pipelines. The demonstration at the Daliuta coal mine in the Shendong mining area has demonstrated that the technologies and processes of distributed underground reservoirs in coal mines are feasible with extensive applicable scope and favorable water preservation effects and can become a strategic measure for water resource protection with mining operations in the ecologically vulnerable western region. 🧑‍🔬

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The Global Distribution of Coal

One of the reasons coal is such an important energy resource is because it is distributed globally. The figure at right, summarizes proven coal reserves by region based on statistics in BP’s 2013 Statistical Review, which was published 12 June 2013. In North America, most coal reserves are held by the U.S. In Europe and Eurasia, most coal reserves are held by the Russian Federation; but, for their size, Germany, Kazakhstan, and Ukraine also have large reserves. In the Asian Pacific countries, Australia (one of the world’s largest coal exporters), China (the world’s largest coal producer), and India have the majority of proven reserves.



Source: 2013 BP Statistical Review (www.bp.com)

Unblotting the Landscape

By Lesley Sloss

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Ask any residential community if they want a new coal mine located in their neighborhood and you are quite likely to see angry placards and letters to the local press before you have even finished the question. This is not surprising. Landscapes throughout Europe, North America, and Asia have been decimated as a result of bad mining practices in the past. There are estimated to be over 550,000 abandoned mines in the U.S. alone.¹ Many of these sites are not only ugly but can cause severe damage to local ecosystems due to long-term environmental effects such as acid mine drainage. With mine reclamation and clean up costing an estimated \$1.5 million/mine, you can understand why unscrupulous mining companies would happily tiptoe away once they have claimed their coal.

However, with coal promising to remain a primary global fuel for many decades to come, coal mining will continue and landscapes will change as a result. Removing coal from the ground is impossible without causing disruption to surrounding land and ecosystems. This disruption is commonly greater in surface mining than in underground mining. In the past, mine

operators concentrated more on efficient production of coal and less on any detrimental effect to the environment. Forests were cut, watercourses were contaminated, and land was left unstable and prone to collapse. Without malpractice in the mining industry in the past, popular children's TV characters such as Skippy, Lassie, and Scooby Doo would have had significantly fewer small boys to rescue from abandoned mine shafts.

"Coal mining in most of the world has undergone a change in ethos."

However, times have changed. Mining operations in most regions of the world are legally required to ensure that the mine site be returned to a minimum standard. In regions such as the EU, North America, Australia, and New Zealand, mining permits will only be granted if a full cradle-to-grave mining plan is prepared demonstrating how the landscape will be returned to a safe and useful condition once the mine is closed. In most cases, monetary bonds must be set aside and will not be released until this work is completed to a minimum standard. These can be corporate surety bonds (to guarantee the contractor will perform the obligation), collateral bonds (short-term debt security, such as cash, letters of credit, or municipal bonds), or self-bonds (legally binding corporate "promises"). Self-bonds are not allowed in some states.

The release of mining bonds often happens in three stages:¹

Phase I: after initial reconstruction and safety work, such as back-filling and drainage control

Phase II: after topsoil replacement and establishment of revegetation

Phase III: meeting the revegetation success requirements

A mine reclamation plan must take into consideration the surrounding environment: the land, soil, water, and ecosystems.¹ However, a successful plan must also consider the local heritage and community. It is not unheard of for buildings of important cultural significance to be relocated and then



An Aerial View of the Park of Northumberlandia, Lady of the North, Constructed near Mining Lands Using Excavated Material

returned following mine closure. The same has happened to communities of lizards, who have been treated to a short vacation while their natural habitat is stripped of subsurface coal and then returned to its former lizard-friendly glory.

The International Council on Mining and Metals works to promote sustainable mining and mine reclamation. The Cerrejón open-pit mine in northeast Colombia, run by Anglo American, is large, covering 70,000 hectares and producing 32 Mt/y of thermal coal. As mining proceeds, where necessary, wildlife is captured by the national environmental authority and released into similar habitats which have not been set aside for mining. Over the last five years, over 26,000 mammals, fish, and reptiles have been rescued and relocated. The mine works closely with the local community and with experts in the field (e.g., The Nature Conservancy and the World Wildlife Fund) to establish initiatives and projects in the area. As part of this work, it was determined that the local sea turtle population was under threat. As a result, a five-stage program was established to monitor the species, to work with indigenous communities to raise awareness, and to establish conservation agreements and programs in the area.

The above example shows how forward planning by ethical mining companies can ensure that mining can minimize its environmental footprint. However, in some cases, mine sites have been abandoned for so long that the ownership is either not known or no longer valid and there is no one to call to task for the damage caused. In these situations, countries must set up their own remediation plans and funding organizations to bring brownfield sites back to being useful and beneficial to the local communities. In the U.S., this is the responsibility of SMCRA—the Surface Mining and Control Reclamation Act of 1977. SMCRA has two programs, one for reclaiming abandoned mine sites and the other to regulate new mining activities. The reclamation of abandoned mines is funded by a levy on all new coal production (35.5 cents/t on surface coal, 15 cents/t on underground coal, and 10 cents/t on lignite). Under SMCRA, between 1980 and 2008, almost 600,000 hectares of land were reclaimed in the Appalachian region alone.

To avoid the repetition of past mistakes, guidelines are readily available on best practices for new mines, much of which is based on common sense. For example, existing rivers or streams should be redirected past the mine site during operation. If this is not possible, then the water must be protected and treated, if necessary with alkaline chemicals or bacterial treatments, to ensure that the local ecosystem is not affected. This does not mean purifying mining water to clean drinking water standards, but rather ensuring that the water

returned to the environment will cause little or no disruption to the existing ecosystem. Returning overly clean water to a naturally peaty watercourse will cause just as much damage to the local ecosystem as returning contaminated water to a “clean” site. A significant amount of pre-planning and biological monitoring is required to evaluate the “natural” condition of an ecosystem prior to mining so that remediation approaches can be tailored accordingly. More gentle, passive treatments based on the flow of water through specially selected soils and plants can be used for long-term neutralization of acid mine drainage following mine closure.

In countries such as South Africa, which are prone to water shortages, companies such as Anglo American are working to ensure that the water produced and collected during mining activities can be treated and provided to the local community as potable drinking water.



A Walking Path in the Northumberlandia, Lady of the North

Removing large quantities of coal from a landscape will inevitably change that landscape. In many cases the final landscape will be significantly topographically lower than was originally the case. The first concern of the mine operator is to ensure that these new contours are safe and structurally sound. There are prescribed limits on how steep mining land can be. This is to avoid repetition of past disasters where unsecured mine spoils have resulted in catastrophic landslides. Guidelines are now available on how best to secure slopes and curves, not only with the use of rocks and appropriate back fill materials and compaction processes, but also with appropriate drainage and topsoil management.



A Side View of Northumberlandia, the Lady of the North

Because lowered mining land can result in the new landscape being below the original natural water line, closed mine sites are often prone to flooding. This can be taken advantage of to form new water features, such as lakes or water parks. Formation of water features can be done in a controlled and safe manner, although some lakes will take years to fill using natural water supplies and rainfall. Alternatively, “flooding” of completed mine sites can be carried out with a bit of flair: Communities within the Lusatia coal mining region of Germany are now benefitting from new water parks, fishing lakes, and marinas as a result of careful re-landscaping and flooding of mined land.

Mine site remediation means not only cleaning up after mining activities but also ensuring that balance has been restored. In some cases, it may take several years to ensure that indigenous local plants and animals have reinstated themselves without long-term damage and that a new equilibrium has been attained.

Even the most basic of mine reclamation plans will require the re-establishment of indigenous plant and animal ecosystems. This usually does not mean simply letting the weeds blow in, even though this laissez-faire approach of leaving the ecosystem to its own devices has actually succeeded in at least one site in Germany where the land has naturally returned to its original grass and wild flower cover. However, there is much more monitoring and evaluation on-going at the site than meets the eye as the company continues to ensure that there are no potential issues which may appear in the longer term.

Returning a mine site to a sustainable condition which can support plant growth requires considerable amounts of monitoring and evaluation. Prior to the commencement of mining, the site will be evaluated to determine the natural condition of the soil—alkalinity, moisture, nutrients, and so on. In some cases, the original topsoil at a mine can be removed and stored for the duration, being returned to its original site once the mining is complete. This requires significant management of the stockpiled material both in terms of safety (to avoid slippage or collapse of large spoil heaps) and condition (piles can become flooded, or dried out over time). If no original topsoil is available, then new topsoil, commonly to a minimum of 1 m, must be sourced and brought in. This topsoil must then be monitored and studied over several months to ensure that there is no upward or inward contamination from acid mine drainage nor any down or outward flow of nutrients due to changes in water flow across the landscape. In the Lusatia region of Germany one closed mine site applied a crop rotation system over seven years to increase the natural fertility of the dumped soils. This encouraged the return of natural humus and reactivated soil-biological processes to support soil structure and plant growth.

Any plants and vegetation brought in to a reclaimed mine site should be suitable for the original site, but must also take into account any changes such as greater exposure to wind. During revegetation, the selection of native species is commonly encouraged, although in some cases non-native species may be used as initial colonizers and these will then be succeeded by native species. Following on from the SMCRA initiatives, the Appalachian Regional Reforestation Initiative developed FRA (the Forestry Reclamation Approach): a five-step approach to encourage the return of indigenous trees to previously cleared areas. The FRA provides guidelines on the suitable preparation of soil and ground cover as well as appropriate tree planting techniques to promote the increase in early and successional trees as well as crop trees in some regions.

With a little bit of forward planning, “landscape wrecking” mining activities can actually be seen as profitable preparation of otherwise neglected land for better use. Mining activities are often accompanied by new communities (work force influx), new road and rail transport links (initially for the coal, but later this can be converted for public use), and new public interest in what to do with this newly accessible piece of property. Some closed mines become forests (providing valuable carbon sinks) or agricultural land. But others have become car parks, shopping malls, theaters, and leisure parks; in the UK, two mine sites are now homes to inspirational pieces of land art by the renowned artist Charles Jencks, which draw thousands of visitors daily as sites of natural beauty.^{1,2}

Coal mining in most of the world has undergone a change in ethos. Coal mining need no longer result in the loss of a local site of natural beauty, but rather offers the potential for a whole new use which may bring significant benefit to the local community and, perhaps as importantly, the local economy. But this can only happen if the mining company, the local authority, and the local community work together from well before the moment the first clump of topsoil is removed.

“Coal mining need no longer result in the loss of a local site of natural beauty, but rather offers the potential for...significant benefit to the local community and...the local economy.”

ADVICE TO POLICY MAKERS

1. Ensure that no mining activities are permitted without a guarantee that the remediation plan is appropriate—not only with respect to protecting the environment but also with consideration for the local landscape and the local community. This guarantee should include a monetary bond appropriate to the size and cost of complete remediation.
2. Learn from the mistakes of those who have failed and benefit from the wisdom of those who have succeeded. A mountain of literature is available—guidelines on best practices from around the world that provide invaluable advice on the easiest route to a successfully closed mine. This can range from advice on local requirements and considerations, such as Mining Resource Activities provided by the Department of Environment and Heritage Protection of the Australian Government,⁴ to the more general guidance on land use and species protection provided by the U.S. Office of Surface Mining Reclamation and Enforcement.⁵

3. Involve the local community in the planning process from the early stages. Local communities are far more likely to be supportive if they know their opinions are being considered.
4. Involve local industry, farmers, and similar regional stakeholders in the planning process from the early stages. The requirements of one party (to fill a large hole left once coal is removed) may line up beautifully with the requirements of another (the desire for a local water park). There is no point in spending millions to make sure that the pH of the soil is suitable for the re-establishment of indigenous trees if the local community college moves in three months later and digs up the site for a new library. Desires, planning, and funding can be combined.
5. Find some means, levies if necessary, to fund work to recover and reclaim abandoned sites. Not only will this limit further environmental damage and begin to mend bridges between the mining companies and the community, innovative reclamation could provide new farm or industrial land, new community sites, and other potentially economically beneficial uses for otherwise wasted land. 🏡

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Case Studies of Successfully Reclaimed Mining Sites

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The process of reclamation of mining lands includes many important considerations and is often far from simple. However, practices related to reclamation have improved significantly in recent years. Although the primary purpose of a mine reclamation plan is usually to minimize the impact to the local environment after a mine is closed, today's mine reclamation plans can encompass much more than just returning a mining site to its natural state. In fact, some closed mines are now forests, farmlands, open spaces, or public parks. In the history of mining operations, there have been too many examples of mining lands that were not properly cared for and, of course, such instances have garnered much publicity. Today, practices are changing and, in many countries, mining permits will not be granted without a complete mine closure plan with the funding secured to support the plan. This article highlights



Local Mongolian Families Benefit from Reclaimed Lands at Former Ereen Mining Site

the strategy, options, and select success stories from mining sites that were reclaimed properly.

WHAT'S INVOLVED

Using best practices to reclaim mining lands after a mine has been closed comes at a cost—an estimated US\$1.5 million per mine.¹ The way this money is spent is based, in part, on how the land will be used, which is often determined after consultation with the local government, NGOs, land owners, and others. The steps for the land reclamation process can include:¹

- Landscape maintenance and design (e.g., map predicting topography, backfill as necessary, examination of drainage)
- Management and restructuring of overburden and soil (e.g., ensuring slope stability)
- Backfilling: Necessary in deep mines to avoid collapse and in surface mines to promote safety and create a smooth landscape
- Topsoil management
- Management and reuse of waste materials

After these steps are taken, the ecosystem can be rebuilt, either actively or passively. The case studies presented here highlight several examples of how ecosystems were rebuilt, which can be contingent on the type of land use intended.

“A successfully reclaimed mining site can be valuable to a community long after mining operations have ceased.”

OPTIONS FOR MINE RECLAMATION

Several options are available for uses for reclaimed mining sites; the selection for the land usage must be based on economic considerations, location, societal needs, and the local ecosystem. There are economic uses for the land

(e.g., industry or housing) as well as productive uses (cultivation, grazing, fishing, parking, etc.). In some cases, it could also be appropriate to open the reclaimed mine site to community use, such as a public park, nature conservancy, etc. The optimal use of closed mining sites must be based on the needs of the local community. For example, in the European Union over 50% of mining lands that have been reclaimed are used for forests or grasslands. However, in China, where there is a shortage of farmland, over 70% of reclaimed mining lands are used for agricultural purposes.² In most cases worldwide, reclaimed mining sites are converted into lands suitable for forestry or agriculture.

CASE STUDIES OF RECLAIMED MINES

Ereen Mine, Mongolia

The Peabody Energy Ereen mining site, located on the remote northern slopes of Mongolia, was acquired by Peabody Energy through a joint venture in 2009. However, the mine was shut down soon after it was acquired. To carry out the mine closure and land reclamation plan, the mine owners allotted the resources to support 60 personnel, including a key choice for leading the closure and reclamation effort, Vern Pfannenstiel, who had extensive experience with mine closure and land reclamation. The most relevant example of his work experience related to his involvement with restoration projects on the Black Mesa (Arizona, U.S.), where he also dealt with a remote location and the need to work with the indigenous people.

In addition to the usual issues that come with mine closure and land reclamation, the remoteness of the Ereen site posed unique challenges. For example, workers had to camp at the site. Without the necessary specialized seeding equipment available locally, such equipment had to be shipped from the U.S., which required five months. The US\$1 million project transformed the former mine site into 44 acres of grassland, which is now used as pastureland for traditional livestock grazing. The project also provided a source of fresh drinking water in an area that did not previously have easy access to potable water.

Peabody Energy carried out the restoration with the nomadic community's cultural practices and land uses in mind. The new community well separates drinking water from livestock water, protecting the purity of water intended for human consumption. The design took into account the harsh conditions typical in Mongolia. The restored landscape also incorporates a surface pond where local herders can bring their cattle, goats, horses, and sheep to drink.

Fencing protects the reclamation area from free-roaming livestock during the establishment phase of the project. Recent monitoring indicates that, with foliage production running at four times that of native lands, the site has strong potential as a hay production resource, critical for feeding local livestock during the harsh winter. All the project's camp supplies, construction materials, and parts were purchased locally or through established manufacturers with branch offices in Mongolia. As well as transferring technical knowledge to the local workforce, Peabody Energy donated materials, supplies, and housing from the project back to the local governments and herders, and employed local families as caretakers. Two local families, one of which has grazed its herds at Ereen for generations, accepted responsibility for ongoing site maintenance and management. Another family took custodianship of the well, and keeps the upstream watershed free from potential contaminants.

Huehnerwasser Catchment at Welzow-South Coal Mine, Germany

A truly unique reclamation project is underway near Cottbus, State of Brandenburg, Germany, at a location called Huehnerwasser (Chicken Creek), where there was previously an open pit mine. This site is owned by the Swedish mining company Vattenfall Europe Mining AG, which is producing lignite in the region and is also responsible for restoration. While the reclamation project was closely watched and



The Former Ereen Mine in Mongolia Restored to Grassland Now Used for Livestock Grazing



Photograph of the Naturally Reclaimed Huehnerwasser (Chicken Creek) Site

monitored, the ecosystem was left to develop itself. This gives researchers a rare opportunity to observe and monitor a fledgling ecosystem.

In 2005, the first steps of the project, which spans approximately six football fields, were to deposit regional sediment, complete grading, and then fence it off. A local groundwater body was allowed to establish on top of a clay layer. After these steps, a relatively minimalist approach was taken.³ Although the area was observed closely, no seeds were planted and no other active steps were taken to encourage plant growth. Then researchers from the Brandenburg University of Technology Cottbus, Technische Universitaet Muenchen, and other institutions were allowed to closely monitor the site. Many diverse groups share this research site in a collaborative effort: For example, plant ecologists closely watch which plants are able to take hold and the order in which plants grow; forestry researchers and soil ecologists watch for changes in the soil. Scientists are studying the influence of several key factors on ecosystem development. Over 70 papers have been published by the collaborative research center to date. The research group has also established a website (www.tu-cottbus.de/projekte/en/oekosysteme) where webcams can be viewed by the public.

The project is set to run for 12 years, which is relatively short as far as ecosystem development is concerned. The results from this project could hold discoveries not only valuable to the

scientific community, but also to the mining industries on how best to encourage the return of closed mines to a natural state.

Northumberlandia, Newcastle, England

Northumberlandia is another truly unusual example of how mining operations and public use of land can go hand in hand. This project was completed in 2012 in the area of Cramlington, Northumberland, in northern England. Actually, Northumberlandia is considered a restoration-first project, wherein mining operations are ongoing while an extra piece of land near the mine was converted to a large public park, partly using material excavated from the mine. The cost of the project was £3 million (double the average costs for a mine reclamation project); both the creation of the park and its maintenance are privately funded by the Banks Mining Group and the Blagdon Estates. The park is open to the public free of charge.

The park was designed by landscape architect Charles Jencks; his vision was to create a park in the shape of a nude woman. The park includes four miles of footpaths in a 47-acre park.

Hunlunbeier, Inner Mongolia, China

Hunlunbeier is located in northeastern Inner Mongolia in China. This area has rich coal reserves, estimated at more than 100 billion tons. The region is also the largest natural grassland in the world, and is characterized by a harsh winter climate and weak surface ecology. The Baorixile coal mine, owned and operated by the Shenhua Group, is located in the region and currently produces over 30 million tons coal per year. The



Photograph of the Face of the Lady of Northumberlandia (Source: Glen Bowman, Wikimedia Commons)



Photograph of the Shenhua Baorixile Site During the Reclamation Process

grasslands are somewhat delicate; for this reason it is important that care is taken during the reclamation process, which is ongoing and carried out simultaneously with mining.

For this site three main steps are employed for the ongoing reclamation: stripping the topsoil prior to mining, stacking and dumping the fill into the open pits, and beautification. Before any mining is begun, surface soil is stripped and stored for future use. The humus soil, which is 0.3–0.5 meters below the surface, is particularly important for supporting plant life. After mining at a particular location is complete, the stripped earth is stacked layer by layer and dumped into the open pits in a stepwise manner. The earth is dumped into the open pits in the largest possible quantities immediately after mining, which limits the amount of stripped earth on the grassland. Finally, the last step of the reclamation process includes beautification of the site, which mainly consists of introducing the appropriate ecology.

Of course, the angle at which the land is recomposed is important to mitigate the risk of collapse. For the Shenhua Baorixile site, a hydraulic excavator and forklift were used to form the wastepile into a series of steps with a 35° angle. The angle of this particular site was selected to limit wastepile height as well as to ensure stability. After the shape of the wastepile was selected, the stored humus soil was spread over the wastepile. Finally, grass seed was sown, and plants began to grow.



Photograph of the Shenhua Baorixile Site after Completion of the Reclamation Process

The Shenhua Group continues to monitor the many reclamation sites in this area and work on them as needed. The backfill and plant work are ongoing as the amount of reclaimed land increases and additional grass and trees are added as necessary. Today, the reclaimed land is used for growing fruit and vegetable crops, which provide an additional source of income to the local community.

From 2006 to 2012, the Shenhua Group invested more than 112 million RMB (~US\$18.7 million) to reclaim mining sites throughout the Baorixile coal mine area. To date, the reclaimed land covers more than 3,850,000 m² (nearly 1000 acres). From 2012 to 2014, Shenhua Group expects to invest another 150 million RMB (US\$25 million) on continued reclamation.

CONTINUED IMPROVEMENT

A successfully reclaimed mining site can be valuable to a community long after mining operations have ceased. Several examples have been provided of successfully reclaimed lands; the final results for these projects included much needed grazing land, a unique park, a research project, and agriculture. Reclaimed mines can benefit the economy and the ecology of the local community if the reclamation process is carried out in a responsible manner. 🌱

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The Coal Industry in British Columbia

Coal is a critical component of the British Columbia economy. B.C. is the home to 10 coal mines, nine of which produce metallurgical coal used to produce steel and other crucial commodities. Today, the statistics behind the importance of the B.C. coal industry to the local economy, as outlined in a recent report prepared by PricewaterhouseCoopers, are clear: coal constitutes nearly 22% of exports; average pay in the B.C.

coal industry is well over double the average in the region, and approximately 26,000 jobs are associated with the B.C. coal industry. In addition, with reserves of 12 billion tonnes of potentially mineable coal and two more coal mines on the way, the coal industry promises to continue to be an important component of the B.C. economy well into the future.

The value of the coal mining industry in B.C. is **\$3.2 billion.**

Coal makes up **21.8%** of all B.C. exports.

The coal industry in B.C. paid **\$715.2 million** in taxes in 2011.

40% of coal produced in Canada comes from B.C.



International Events and Politics

11 April 2013 – At a World Energy Outlook (WEO) workshop in Rio de Janeiro, Brazilian officials, representatives from industry, energy experts, and IEA representatives met to discuss work for WEO 2013. Brazil will be the key country focus for the WEO 2013.

22 April 2013 – The World Coal Association announced that GE Mining has joined as a Corporate Member. GE Mining offers products and services for each step of the mining process. 🏠

Recent Select Publications

The Australian Coal Industry – Adding Value to the Australian Economy – Sinclair Davidson and Ashton de Silva prepared this report for the Australian Coal Association as a follow-up to the Reserve Bank of Australia's report that measured the size of the resource economy, which was 18% of gross value in 2011–2012. The new report focused on only the coal industry and found that the coal economy made up 3.12% of gross value in 2011–2012. The full report is available online at www.australiancoal.com.au

Annual Energy Outlook 2013 – The U.S. Energy Information Administration released its annual report of the projections for the energy sector. Of particular interest to the coal industry is the discussion of the competition between coal and natural gas in the electric power sector. The report suggests that in the near term natural gas and coal will continue to compete for electricity dispatch. In the longer term (to 2040), natural gas-based electricity generation will grow while coal-based power generation will fall. Even so, in 2040 natural gas is projected to provide 30% of electricity while coal will provide 35%. The full report is available online at www.eia.gov/forecasts/aeo

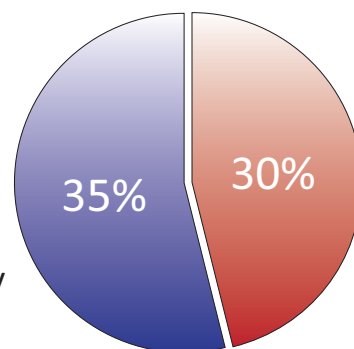
Call to Reduce Domestic and Imported Emissions and Address UK's Competitiveness Risks – Prepared by the Committee on Climate Change, this report examines ways to reduce carbon emissions from the UK and still maintain competitiveness. One major conclusion from the report is that the carbon footprint of the UK has increased approximately 10% over the past two decades, partly due to growth in imported emissions. The report suggests that for the UK to meet its emissions goals, a global agreement to reduce carbon emissions will be necessary.

China: The Illusion of Peak Coal – Wood Mackenzie released a report that projected China will not see a peak in thermal coal demand before 2030 with demand to reach nearly 7 btpa. The large coal demands estimated in the report take into account significant gains in energy efficiency, without which the coal demand will be even greater than expected.

Emerging Workforce Trends in the U.S. Energy and Mining Industries: A Call to Action – The National Academy of Sciences recently released a report led by the National Research Council summarizing trends for the energy and mining workforce in the U.S. The report includes discussion on mature industries (oil and gas, nuclear, and mining), emerging sectors (solar, wind, geothermal, and CCUS), and the electricity grid. One of the key conclusions is that the workforce in the U.S. energy and mining sector is older than the general workforce—highlighting the critical need to fill workforce gaps in the future. The report is available online at www.nap.edu

Global Tracking Framework – The International Energy Administration led this multi-agency effort under the Sustainable Energy for All initiative (SE4ALL); the purpose of this report is to create a starting point against which progress can be measured from now until 2030. The three main objectives of the SE4ALL initiative are achieving universal access to modern energy services, doubling the global rate of improvement in energy efficiency, and doubling the share of renewable energy. This report found that, as of 2010, 17% of the global population has no access to electricity, 41% rely on biomass or wood for cooking, energy efficiency has increased at a rate of approximately 1.3% per year, and 80% of the world's energy is supplied by fossil fuels. This report is available at www.iea.org/publications 🏠

In **2040**
natural gas is
projected in the
U.S. to provide
30% of electricity
while coal will
provide **35%**.



Key Meetings and Conferences

Select Coal and Energy-Focused Conferences

Globally there are numerous conferences and meetings geared toward the coal and energy industries. The table below highlights a few such events. If you would like your event listed in *Cornerstone*, please contact the Executive Editor at cornerstone@wiley.com.

Conference Name	Dates	Location	Website
23 rd World Mining Congress	Aug. 11—Aug. 15	Montreal, Quebec, Canada	www.wmc-expo2013.org
Coal-Gen 2013	Aug. 14—Aug. 16	Charlotte, North Carolina	www.coal-gen.com/index.html
2013 Pittsburgh Coal Conference	Sept. 16—Sept. 19	Beijing International Convention Center, Beijing, China	www.engineering.pitt.edu/PCC/
International Conference on Coal Science & Technology	Sept. 30—Oct. 3	Penn Stater Hotel and Conference Center, Pennsylvania, PA, USA	www.iccst.info/live/index.php?c=k
Longwall Conference 2013	Oct. 14—Oct. 15	Crowne Plaza, Hunter Valley, NSW, Australia	www.informa.com.au/conferences/mining-conference/operational-mining-coference/longwall-conference
33 rd Coaltrans World Coal Conference (Featured Coaltrans Conference)	Oct. 20—Oct. 22	Estrel Convention Centre, Berlin, Germany	www.coaltrans.com (Note that several other Coaltrans conferences are listed on the website.)

2013 Pittsburgh Coal Conference

The Pittsburgh Coal Conference will be held Sept. 16–19 in Beijing, China. This conference is dedicated to providing a unique opportunity for in-depth and focused exchange of technical information and policy issues among representatives from industry, government, and academia throughout the world.



Meeting Spotlight

The U.S. National Coal Council (NCC), a federal committee that advises the U.S. Secretary of Energy on request, held a meeting in Washington, DC, on 17 May 2013. There were several notable events at this meeting, which consisted of four presentations from distinguished speakers on the topics of the future of coal and a review of the NCC reports released since 2000, cyber security and how it could affect the electric sector, and a new technology that combines coal and nuclear power to convert coal to liquids fuels. In addition, Janet Gellici addressed the group formally as the Executive VP and COO of the NCC.

The main event for the meeting were the remarks given by Chris Smith, the Acting Assistant Secretary for Fossil Energy. Mr. Smith quickly launched into a discussion of CCS and the need for tech-

nology development. He said, “The clean energy economy of the future is going to be a carbon constrained world...there are going to be winners and there are going to be losers...” He made the case that the countries which develop clean energy technologies first will be the “winners” and, therefore, the current U.S. Administration has committed \$6 billion in CCS development and demonstration pairing extensively with private-sector partners. He also stated that, in the end, the



U.S. Acting Assistant Secretary for Fossil Energy Chris Smith

license to operate CCS would come from communities, not regulators, and those involved with CCS must be prepared to use fundamental science, data, and demonstrations to prove CCS is safe. Mr. Smith acknowledged that work must be done to break down the barriers between different organizations in the federal government. Specifically, after asked about the prospect of improving coal-fired power plant efficiency *before* implementing

CCS, Mr. Smith responded that the Department of Energy and Environmental Protection Agency must do a better job working together and that we should “check back in” with him.

The full remarks of the Acting Assistant Secretary and all the other presentations are available online at www.nationalcoalcouncil.org. 🗣️

Business Movers and Shakers

25 March 2013 – Peabody announced that its Energy Chairman and CEO, Gregory H. Boyce, will serve as Chairman of the IEA Coal Industry Advisory Board (CIAB). Mr. Boyce has been the CIAB Deputy Chairman since November 2010. A recent CIAB report entitled “21st Century Coal: Advanced Technology and Global Energy Solution” is available on the IEA website: www.iea.org/publications/insights



Gregory H. Boyce
Energy Chairman and CEO

27 March 2013 – Caterpillar announced that it will supply CONSOL Energy Inc. with longwall equipment and roof supports totaling nearly US\$300 million.

7 April 2013 – Sinopec announced that it will be investing 70 billion yuan (US\$11.3 billion) to build China's largest coal-to-gas project, which will produce 8 billion cubic meters of natural gas each year. It is expected that the project will require 8–10 years to complete. The natural gas will be transported through the Sinopec Group's existing pipelines.

8 April 2013 – Orica announced that its Chairman Peter Duncan will retire in January 2014 and will be succeeded by Russell Caplan, who is currently a non-executive Director of Aurizon Limited (formerly QR National Limited). Orica also announced that Maxine Brenner had been appointed as a non-executive Director.

15 April 2013 – China Huadian announced that, in collaboration with Tsinghua University, it has successfully developed a technology to convert coal to aromatics. The company will now work to advance this technology to the one million tons/yr scale later this year at a demonstration-scale polyproduction project located in Yulin, Shaanxi province.

18 April 2013 – BHP Billiton announced the appointment of Andrew Mackenzie as its new CEO and also announced the senior management team effective as of 10 May 2013.



Andrew Mackenzie
CEO BHP Billiton

29 April 2013 – BHP Billiton announced that it will sell its mining operation in Pinto Valley and the San Manuel Arizona Railroad Company to Capstone Mining Corporation for US\$650 million.

30 April 2013 – Techdrill International Ltd and Total SA have signed an agreement to effectively end the litigation which has been ongoing since early 2006.

21 May 2013 – Workers in Australia went on strike at locations such as Australia's Newcastle port to protest potential revisions to their contracts, which were reportedly necessary due to the lower commodity cost for coal, which has already cost up to 9000 jobs in Australia according to a report commissioned by the Australian Coal Association.

28 May 2013 – The Indian state government in the Alwar district has announced that, as a part of its campaign against illegal mining, eight people have arrested and 43 illegal mines have been closed.

29 May 2013 – Glencore Xstrata announced that the President of Colombia, Juan Manuel Santos, officially opened the new port, Puerto Nuevo, which is a US\$550 million investment by Glencore and boasts a train unloading station capable of accepting 8000 t/h and a 1.7 km access pier.

30 May 2013 – BHP Billiton, the world's largest mining company, announced to investors that it will not invest in any new coal projects, and also plans to cut spending related to exploration. 🗣️

International Outlook

AUSTRALIA

In an effort supported largely by the Australian Workers Union, the Tarkine region in Tasmania, Australia, has been blocked from being listed as a national heritage location, which would have resulted in increased difficulty to obtain mining permits in the region.



Road through Tarkine wilderness, Tasmania, Australia. The Tarkine region is located in the north-west of Tasmania. The area encompasses 447,000 hectares of wilderness including the Southern Hemisphere's largest single tract of temperate rain forest.

CHINA

Coal production and import volumes in China were 1469 million tonnes and 136 million tonnes respectively, in the first five months of 2013, while import volumes were up 20.9% from the previous year. In addition, although total power generation grew by 4%, thermal power generation grew only 2.1% from the previous year.

The China Taiyuan Coal Transaction Price Index was recently launched; this new index will better take into account the rate of coal production and will better guide coal production and sales. The index will initially be based on Shanxi Province, but will

then incorporate price monitoring in the Inner Mongolia Autonomous Region as well as Shaanxi and Henan by the end of this year.

INDIA

The Indian government and the Indian Planning Commission projected that by 2017 India could be importing approximately 187 million tons annually and this may be an underestimate—there are 30 GW of planned coal-fired power plants, and many of these plants have not finalized their coal supplies.

INDONESIA

The head of the coal division of the state-owned Perusahaan Listrik Negara (PLN) in Indonesia stated that he expects domestic coal demand to surge and by 2020 it is possible that Indonesia may have to import coal to keep up with rising demand.

JAPAN

In the wake of the 2011 Fukushima meltdown the Japanese government has announced plans to facilitate increasing coal-fired electricity generation by reducing the projected permitting time from four years to under 12 months. In addition, by October, the government also plans to revise the commitments to reduce carbon emissions by 2020 by 25% from 1990 levels. Tokyo Electric, the operator of the Fukushima plant, has called for up to 2600 MW of new coal-based capacity.

RUSSIA

Russia, the world's sixth-largest coal exporter, is showing few signs of growth based on infrastructure constraints (e.g., rail car shortages and ports that already run close to capacity) with few plans to address these infrastructure limitations. However, if coal prices rise there could be potential to increase exports of East Siberian coal from ports in the Far East.

Total Power Generation
in China Grew by

4.0%.



Global energy consumption
grew by

2.5% in 2011.





The UK Government is Considering an Energy Bill That Could Strongly Influence The Nation's Future Energy Mix

UNITED KINGDOM

The UK parliament is debating a bill to spend £110 billion on electricity plants. Initial plans for the spending include building

up to 26 GW of power plants fueled by natural gas. The government's climate advisor has proposed that, by 2050, £100 billion could be saved if this money was spent on wind, nuclear, and carbon capture.

UNITED STATES

The U.S. Department of Energy conditionally approved a Texas-based proposal to export LNG. If it moves forward, the Freeport LNG expansion could result in the export of 1.4 billion cubic feet of LNG per day. This is only the second such project to receive approval, although there are currently at least 20 LNG export projects seeking approval.

The U.S. Court of Appeals for the D.C. Circuit ruled that the EPA could veto a Clean Water Act permit after it had been issued. Among other groups, the National Mining Association expressed concern that this sets a precedent that the EPA can retroactively revoke permits issued by other government agencies, which could create excessive uncertainty in an already-lengthy mining permitting process. 🤖

From the WCA

Energy & Environment Workshop – 20 May 2013, Beijing, China

One of the WCA's main activities is providing information about coal, its uses and impacts, and how it can meet environmental challenges at international workshops and conferences. A recent example of such an activity was the WCA-sponsored energy and environment workshop. The four presentations at



Photograph of the Energy & Environment Workshop Held at the Oriental Bay International Hotel, Beijing, China

this workshop were focused on two main topics: the coal industry with the global development of shale gas and the current status of emissions control from coal-fired power plants. The workshop was chaired by Godfrey Gomwe, CEO of Anglo American Thermal Coal and the Chairman of the Energy & Climate Change Committee of the WCA. The presenters and the presentation topics were:

Fred Palmer, SVP of Peabody Energy and former Chairman of the WCA – The NCCs Vision for Social Development Through 21st Century Coal

Zhu Jie, Deputy Director General and Researcher, Strategy Department of Oil and Gas Resource Strategy Research Center, Ministry of Land and Resources of the People's Republic of China – Shale Gas Exploration in China

Pan Li, Director of the Research Office of the China Electricity Council – Current Status of Pollutant Control for Coal-Fired Power Plants in China

Ming Sung, Chief Representative, Asia Clean Energy Innovation Initiative of the Clean Air Task Force – Curbing the Emission of Conventional Pollutants from U.S. Power Plants

The presentations from this workshop are available at www.worldcoal.org/resources

World Coal Association Leadership & Excellence Awards 2013

The WCA Leadership and Excellence Awards program has been established to recognize outstanding achievement and innovation in the international coal industry and its value chain. The very first World Coal Association Awards program will cover the following areas:

- environmental practice
- low-carbon technologies
- innovative coal technologies
- mining safety

The Awards will be presented during the International Coal & Climate Summit in Warsaw on 18 November, running in parallel to the UN climate change negotiations in Warsaw (COP19). The Summit will bring together the leadership of the world's largest coal producing companies, other business-leaders, senior policy makers, development banks, academics, and NGO representatives to discuss the role of coal in the global economy, against the backdrop of the climate change agenda.

Categories & Judging Criteria

WCA Award for Excellence in Environmental Practice

This award will recognize outstanding contribution or potential in the area of reducing the environmental footprint of coal, at any stage of the coal value chain. This can include, for example, improvements in the environmental footprint of coal mining or coal use in relation to water quality, air pollution control, or land reclamation.

WCA Award for Excellence in Low-Carbon Technologies

This award will acknowledge the best technological development in the area of reducing the greenhouse gas footprint of coal, at any stage of the coal value chain. Entries for this award can include, for example, technological innovations in the area of coal use and coal mining, as well as coal cleaning or processing. In the energy sector the two main areas of focus will be high-efficiency low-emissions coal combustion technologies as well as carbon capture, use, and storage.

WCA Award for Leadership on Innovative Coal Technologies

Projects or products considered for this Award will need to demonstrate the potential to make a significant impact on the future use of coal or the coal industry. This can include, for example innovative processes such as coal gasification, coal-to-liquids, or coal-to-chemicals.



World Coal Association
Leadership & Excellence
Awards 2013

WCA Award for Leadership on Mining Safety

This Award will acknowledge a project or a product that enhances the coal industry's safety record.

For each of the Awards the Judges will be looking for evidence of an innovative approach, good prospects for wider application, and cost-effective deployment prospects.

Eligibility

The Awards are open to companies and organizations working in the field of coal mining, coal use or coal technologies, including non-WCA members and companies that are not producing coal.

Closing Date

16 September 2013

Entry form

If you would like your company/organization to be considered for the 2013 WCA Leadership and Excellence Awards please fill in the Entry Form on the WCA website.

www.worldcoal.org/resources/wca-leadership-and-excellence-awards

Judging Procedure

Entries will be considered in two stages.

Stage 1 – a jury consisting of former and current WCA Chairmen, WCA sub-committees' Chairs, and external stakeholders will vote for their preferred entries. The top three applications for each category will be shortlisted for the Awards.

Stage 2 – the WCA Executive Committee will select a winner for each category from the shortlisted candidates. 🏆

Corrigendum: Issue 1, page 60: "Haining" was incorrectly used in the image caption. The correction caption is "Shenhua Guohua Ninghai Power Plant"



International Coal & Climate Summit

Ministry of Economy, Warsaw
18-19 November 2013

“ Our industry is given the responsibility to produce almost a third of the world's energy every year. We also play a major role in producing materials needed for modern societies, such as steel and cement. We recognise that as a global industry, we have global responsibilities, which include working to ensure that coal meets international climate objectives.

As Chairman of the World Coal Association, I am pleased to announce the inaugural International Coal & Climate Summit, which will bring together business leaders, policy-makers, NGOs, researchers and other thought-leaders to discuss these challenges. ”

Dr Zhang Xiwu,
World Coal Association Chairman
and Chair of the Shenhua Group

The industry's most important event of the year will be held at the Ministry of Economy of Poland, in Warsaw, during the UN climate change negotiations (COP19) on 18-19 November 2013.

To find out more about how you can attend, contact:

Aleks Tomczak, WCA, atomczak@worldcoal.org
Renata Kałużna, SCC, renata.kałużna@scc.com.pl

International Coal & Climate Summit website:
<http://scc.com.pl/konferencje/en/cct>



21st Century Coal means state-of-the-art advances across the industry in areas of safety, productivity, sustainability, mine reclamation, and near-zero emissions technology in recent decades.



CORNERSTONE