GROUNDWORK
Furthering the Influence of Earth Science

A contribution to our dialogue on energy choices

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INTRODUCTION

The United States and much of the rest of the world must imminently achieve dramatic changes in energy production and consumption. This is driven primarily by the need to limit greenhouse gas production, principally CO_2 (U.S. Senate Committee on Environment and Public Works, 2009; Intergovernmental Panel on Climate Change [IPCC], 2007), and by constraints on oil supplies. A near-complete transition to new and renewable sources is clearly necessary; however, this may take several decades to achieve. We must also use our current energy sources wisely, with regard to both effective utilization and environmental constraints. Our decisions must be considered carefully, because they will be far reaching.

The largest source of U.S. energy is petroleum, 58% of which is imported. Natural gas and coal contribute approximately equal proportions (23.8% and 22.5%, respectively) but with largely different end uses (U.S. Energy Information Admin. [EIA], 2008). Proponents advocate increased use of natural gas for electricity, with the goal of supplanting a large portion of our current coal use. Because CO_2 emissions from natural gas are generally ~56% of those emitted by an energy-equivalent amount of coal (U.S. EIA, 1998), this would substantially limit greenhouse gases. However, increasing gas production on the required scale would create pronounced attendant environmental impacts. Natural gas is important as a clean fuel, but replacing coal might not be reasonably achievable or environmentally sound.

An incomplete understanding of coal's contribution to our energy supply (i.e., electricity, which is how most non-transportation energy is delivered) and the current level of gas development may lead to misconceptions concerning our use of these resources. Our electricity needs are expected to grow. Greenhouse gas–reducing innovations, such as plug-in hybrid vehicles and electric-powered mass transit, are likely to intensify this growth. It is difficult to visualize meeting these needs over the short-term without coal.

CURRENT UTILIZATION AND TRENDS

Natural gas currently makes up ~24% of our domestic energy supply (renewable energy included), and 30% of U.S. natural gas production is used to generate electricity, comprising ~17% of the total. Coal, on the other hand, provides 51% of our electricity (U.S. EIA, 2008). It would be necessary to triple gas generation to replace current coal usage, excluding any concurrent increases in other gas uses. Renewable energy sources provide ~7% of our total domestic supply, with ~50% used for electricity. Dramatic increases in renewable energy would be needed in order to replace coal. Nuclear power may provide a potential solution, but this warrants a separate discussion on its own relative merits.

The United States has substantial gas resources. Domestic natural gas production in 2008 was 26 trillion cubic feet. Production has increased annually for decades, except for several brief periods following the mid-1970s (U.S. EIA, 2009a). Most remaining (on-shore) supplies are now believed to occur in nonconventional and emerging resources (e.g., coalbed methane, discontinuous stratigraphic traps, shale gas). Development typically requires more concentrated, closely spaced drilling than for past conventional resources.

There are presently ~450,000 gas wells onshore in the United States (U.S. EIA, 2009b; American Gas Association, 2007). In recent years, drilling has occurred at an unprecedented rate, just to meet current demand. Development scenarios can include hundreds or thousands of wells (U.S. Bureau of Land Management [BLM], 2008a, 2008b).

ILLUSTRATIVE COAL AND GAS DEVELOPMENT AREAS

A substantial portion of U.S. coal is produced from a series of mines in Wyoming's Powder River Basin, from the Antelope and North Antelope/Rochelle mine complex in the south to the Buckskin and Rawhide mines in the north (USGS, 2001; Wyoming State Geological Survey, 2002). In 2008, these mines produced ~446 million tons of coal (~34% of U.S. production, as of 2007), which was used almost entirely to generate electricity (BLM, 2009). Not all coal mining is equal, but the relatively subdued topography and generally arid conditions at this locality limit environmental damage. However, burned in conventional power plants, this coal would produce ~3600 lbs of CO_2 per ton, with an average Btu content of ~8500 Btu/lb and 212.7 lbs of CO_2 per million Btu (U.S. EIA, 1994).

Clearly, we can no longer sustain emissions of this scale if we are to achieve the needed reductions in greenhouse gases. Yet the coal mined in this region alone contributes substantially (~18.9%) to the U.S. electricity supply—slightly more, in fact, than the total contributed by natural gas.

Coalbed methane is widely produced from subsurface coal seams to the west of the Powder River Basin coal mining areas. The wells are shallow, requiring less surface disturbance and

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more limited production facilities than necessary for "conventional" gas wells. By November 2008, ~27,000 wells had been drilled in the Wyoming portion of the basin, most of these since 2000 (Wyoming Oil and Gas Conservation Commission, 2010a). Complete development may require more than 50,000 wells, and recoverable reserve estimates are as high as 28 TCF, a volume approximately equal to one year's U.S. gas supply (BLM, 2001). Similar, but less extensive, coalbed methane development is occurring elsewhere in Wyoming, Colorado, Utah, and other states. Data regarding coalbed methane in these regions are available from federal and state agencies (USGS, 2001, 2010; BLM, 2008; Wyoming Oil and Gas Conservation Commission, 2010b).

Concentrated development, by deep wells and using "conventional" surface facilities, is occurring in the prolific Jonah and Pinedale Anticline oil and gas fields in western Wyoming. As many as 9,000 additional wells are anticipated within the surrounding area over the next 10–20 years (BLM, 2008a, table 13 therein).

Colorado's Piceance Basin, the Uintah Basin/Book Cliffs area of Utah, and other parts of Wyoming have also experienced accelerated oil and gas development. Thousands more wells are expected in these areas (BLM, 2007, 2008c). Similar natural gas resources exist at other localities throughout the western U.S. and on other parts of the country, where comparable levels of development are likely.

RECONSIDERING NATURAL GAS vs. COAL

Natural gas production should be balanced against impacts on other resources and land uses. Even if sufficient resources exist, it is not certain that accelerating production to triple its current rate, or more, is achievable within a short time. When environmental constraints and consequences and historically increasing consumption are considered, the goal of supplanting coal production becomes even more daunting.

Impacts associated with drilling can be managed, but the level of activity in recent years, driven by existing demand, is taxing our ability to mitigate them. Some resources (e.g., water, air quality, sensitive wildlife species) have been adversely affected or placed at risk. The U.S. Government Accountability Office (2005) has documented that federal offices responsible for managing resources on western U.S. public lands, where most future energy extraction is expected, were increasingly unable to cope with rising levels of development several years ago. Production at the projected levels is likely to overwhelm efforts to mitigate environmental effects, resulting in legal challenges, environmental degradation, and other unacceptable consequences.

If the true cost of using natural gas as a replacement for coal is considered, it might be wiser to limit coal's emissions than to dismiss its use entirely. Several cooperative carbon-capture/sequestration research efforts are underway (National Energy Technology Laboratory, 2009). Given the urgency of the climate situation and the magnitude of coal's contribution to our energy supply, accelerated research and development is warranted. Certainly, the coal and electric utility industries must step up as principal participants in sequestration research, development, and practice.

The geologic community can play a key role in the national dialogue regarding our energy supply. Pertinent data are readily available and accessible using the following references. Development areas can be examined easily using Google Earth.

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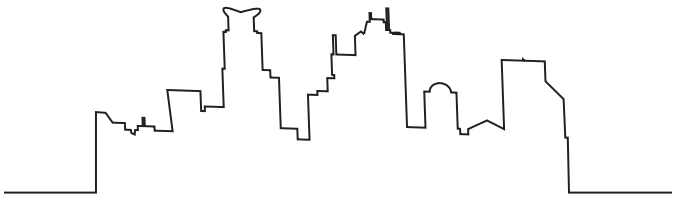

GSA ANNUAL MEETINGS LOOK TOWARD THE FUTURE

2011
Minneapolis, Minnesota, USA
(9–12 October)

2012
Charlotte, North Carolina, USA
(4–7 November)

2013
Denver, Colorado, USA
(27–30 October)

2014
Vancouver, British Columbia, Canada
(19–22 October)

2015
Baltimore, Maryland, USA
(1–4 November)