EXECUTIVE SUMMARY

DRILL, BABY, DRILL

CAN UNCONVENTIONAL FUELS USHER IN A NEW ERA OF ENERGY ABUNDANCE?

BY J. DAVID HUGHES

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World energy consumption has more than doubled since the energy crises of the 1970s, and more than 80 percent of this is provided by fossil fuels. In the next 24 years world consumption is forecast to grow by a further 44 percent—and U.S. consumption a further seven percent—with fossil fuels continuing to provide around 80 percent of total demand.

Where will these fossil fuels come from? There has been great enthusiasm recently for a renaissance in the production of oil and natural gas, particularly for the United States. Starting with calls in the 2008 presidential election to “drill, baby, drill!,” politicians and industry leaders alike now hail “one hundred years of gas” and anticipate the U.S. regaining its crown as the world's foremost oil producer. Much of this optimism is based on the application of technologies like hydraulic fracturing (“fracking”) and horizontal drilling to previously inaccessible shale reservoirs, and the development of unconventional sources such as tar sands and oil shale. Globally there is great hope for vast increases in oil production from underdeveloped regions such as Iraq.

However, the real challenges—and costs—of 21st century fossil fuel production suggest that such vastly increased supplies will not be easily achieved or even possible. The geological and environmental realities of trying to fulfill these exuberant proclamations deserve a closer look.

Context: History and forecasts

Despite the rhetoric, the United States is highly unlikely to become energy independent unless rates of energy consumption are radically reduced. The much-heralded reduction of oil imports in the past few years has in fact been just as much a story of reduced consumption, primarily related to the Great Recession, as it has been a story of increased production. Crude oil production in the U.S. provides only 34 percent of current liquids supply, with imports providing 42 percent (the balance is provided by natural gas liquids, refinery gains, and biofuels). In fact, the Energy Information Administration (EIA) sees U.S. domestic crude oil production—even including tight oil (shale oil)—peaking at 7.5 million barrels per day (mbd) in 2019 (well below the all-time U.S. peak of 9.6 mbd in 1970), and by 2040 the share of domestically produced crude oil is projected to be lower than it is today, at 32 percent. And yet, the media onslaught of a forthcoming energy bonanza persists.

Metrics: Size, Rate of Supply, and Net Energy

The metric most commonly cited to suggest a new age of fossil fuels is the estimate of *in situ* unconventional resources and the purported fraction that can be recovered. These estimates are then divided by current consumption rates to produce many decades or centuries of future consumption. In fact, two other metrics are critically important in determining the viability of an energy resource:

- ***The rate of energy supply***—that is, the rate at which the resource can be produced. A large in situ resource does society little good if it cannot be produced consistently and in large enough quantities, characteristics that are constrained by geological, geochemical and geographical factors (and subsequently manifested in economic costs). For example, although resources such as oil shale, gas hydrates, and in situ coal gasification have a very large in situ potential, they have been produced at only miniscule rates if at all, despite major expenditures over many years on pilot projects. Tar sands similarly have immense in situ resources, but more than four decades of very large capital inputs and collateral environmental impacts have yielded production of less than two percent of world oil requirements.

- *The net energy yield* of the resource, which is the difference between the energy input required to produce the resource and the energy contained in the final product. The net energy, or "energy returned on energy invested" (EROEI), of unconventional resources is generally much lower than for conventional resources. Lower EROEI translates to higher production costs, lower production rates and usually more collateral environmental damage in extraction.

Thus the world faces not so much a *resource* problem as a *rate of supply* problem, along with the problem of the collateral environmental impacts of maintaining sufficient rates of supply.

DATA: PRODUCTION, TRENDS, AND CONSTRAINTS

This report provides an in-depth evaluation of the various unconventional energy resources behind the recent "energy independence" rhetoric, particularly shale gas, tight oil ("shale oil"), and tar sands. In particular, the shale portions of this report are based on the analysis of production data for 65,000 wells from 31 shale plays using the DI Desktop/HPDI database, which is widely used in industry and government.

Shale gas

Shale gas production has grown explosively to account for nearly 40 percent of U.S. natural gas production; nevertheless production has been on a plateau since December 2011 —80 percent of shale gas production comes from five plays, several of which are in decline. The very high decline rates of shale gas wells require continuous inputs of capital—estimated at $42 billion per year to drill more than 7,000 wells—in order to maintain production. In comparison, the value of shale gas produced in 2012 was just $32.5 billion.

The best shale plays, like the Haynesville (which is already in decline) are relatively rare, and the number of wells and capital input required to maintain production will increase going forward as the best areas within these plays are depleted. High collateral environmental impacts have been followed by pushback from citizens, resulting in moratoriums in New York State and Maryland and protests in other states. Shale gas production growth has been offset by declines in conventional gas production, resulting in only modest gas production growth overall. Moreover, the basic economic viability of many shale gas plays is questionable in the current gas price environment.

Tight oil (shale oil)

Tight oil production has grown impressively and now makes up about 20 percent of U.S. oil production. This has helped U.S. crude oil production reverse years of decline and grow 16 percent above its all-time post-1970 low in 2008. More than 80 percent of tight oil production is from two unique plays: the Bakken in North Dakota and Montana and the Eagle Ford in southern Texas. The remaining nineteen tight oil plays amount to less than 20 percent of total production, illustrating the fact that high-productivity tight oil plays are in fact quite rare.

Tight oil plays are characterized by high decline rates, and it is estimated that more than 6,000 wells (at a cost of $35 billion annually) are required to maintain production, of which 1,542 wells annually (at a cost of $14 billion) are needed in the Eagle Ford and Bakken plays alone to offset declines. As some shale wells produce substantial amounts of both gas and liquids, taken together shale gas and tight oil require about 8,600 wells per year at a cost of over $48 billion to offset declines. Tight oil production is projected to grow substantially from current levels to a peak in 2017 at 2.3 million barrels per day. At that point, all drilling locations will have been used in the two largest plays (Bakken and Eagle Ford) and production will collapse back to 2012 levels by 2019, and to 0.7 million barrels per day by 2025. In short, tight oil production from these plays will be a bubble of about ten years' duration.

Tar sands

Tar sands oil is primarily imported to the U.S. from Canada (the number one supplier of U.S. oil imports), although it has recently been approved for development in Utah. It is low-net-energy oil, requiring very high levels of capital inputs (with some estimates of over $100 per barrel required for mining with upgrading in Canada) and creating significant collateral environmental impacts. Additionally it is very time- and capital-intensive to grow tar sands oil production, which limits the potential for increasing production rates.

Production growth forecasts have tended to be very aggressive, but they are unlikely to be met owing to logistical constraints on infrastructure development and the fact that the highest quality, most economically viable portions of the resource are being extracted first. The economics of much of the vast purported remaining extractable resources are increasingly questionable, and the net energy available from them will diminish toward the breakeven point long before they are completely extracted.

Other resources

Other unconventional fossil fuel resources, such as oil shale, coalbed methane, gas hydrates, and Arctic oil and gas—as well as technologies like coal- and gas-to-liquids, and in situ coal gasification—are also sometimes proclaimed to be the next great energy hope. But each of these is likely to be a small player in terms of rate of supply for the foreseeable future even though they have large *in situ* resources.

Deepwater oil and gas production make up a notable (yet still small) share of U.S. energy consumption, but growth prospects for these resources are minimal, and opening up coastal areas currently under moratoriums would expand access to only relatively minor additional resources. Production of biofuels, although not fossil fuels, is projected to be essentially flat for at least the next two decades (while requiring significant fossil fuel inputs) and will remain a minor player in terms of liquid fuel consumption.

CONCLUSION

The U.S. is a mature exploration and development province for oil and gas. New technologies of large scale, multistage, hydraulic fracturing of horizontal wells have allowed previously inaccessible shale gas and tight oil to reverse the long-standing decline of U.S. oil and gas production. This production growth is important and has provided some breathing room. Nevertheless, the projections by pundits and some government agencies that these technologies can provide endless growth heralding a new era of "energy independence," in which the U.S. will become a substantial net exporter of energy, are entirely unwarranted based on the fundamentals. At the end of the day fossil fuels are finite and these exuberant forecasts will prove to be extremely difficult or impossible to achieve.

A new energy dialogue is needed in the U.S. with an understanding of the true potential, limitations, and costs—both financial and environmental—of the various fossil fuel energy panaceas being touted by industry and government proponents. The U.S. cannot drill and frack its way to "energy independence." At best, shale gas, tight oil, tar sands, and other unconventional resources provide a temporary reprieve from having to deal with the real problems: fossil fuels are finite, and production of new fossil fuel resources tends to be increasingly expensive and environmentally damaging. Fossil fuels are the foundation of our modern global economy, but continued reliance on them creates increasing risks for society that transcend our economic, environmental, and geopolitical challenges. The best responses to this conundrum will entail a rethink of our current energy trajectory.

Unfortunately, the "drill, baby, drill" rhetoric in recent U.S. elections belie any understanding of the real energy problems facing society. The risks of ignoring these energy challenges are immense. Developed nations like the United States consume (on a per capita basis) four times as much energy as China and seventeen times as much as India. Most of the future growth in energy consumption is projected to occur in the developing world. Constraints in energy supply are certain to strain future international relations in unpredictable ways and threaten U.S. and global economic and political stability. The sooner the real problems are recognized by political leaders, the sooner real solutions to our long term energy problem can be implemented.