

Can The United States Drill Its Way to Energy Security?

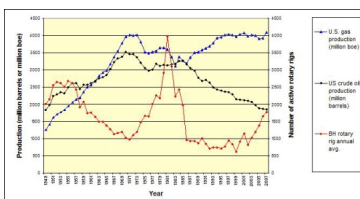
Written by Timothy D. Kailing
Sunday, 14 December 2008 00:00

Those who advocate increased oil and gas drilling generally, and quite reasonably, assume that increased drilling will result in significantly increased production of oil and gas. Drilling is certainly one of the rate-limiting steps to the eventual production of oil and gas. But beyond this crude notion that more is better, the innumerate naïveté of many energy projections is staggering.

In fact, many drilling advocates implicitly assume that the energy gained from increased drilling will be roughly linear: that is, doubling drilling effort is expected to eventually bring something like double the energy resources to market. In reality, the historical data give overwhelming and unequivocal evidence that the energy return on drilling in the United States will certainly be far less than this. For generations now, the energy return on increased drilling has been a quantitative relationship of sharply diminishing returns with increased drilling effort. In fact, for the last several decades, the relationship of drilling effort and energy return has been so unfavorable that there is little evidence that even vastly increased drilling will significantly increase U.S. domestic energy production. This stark fact must be incorporated into any strategic energy planning. To do otherwise is to put hope entirely before experience.

Drilling Activity and Oil and Natural Gas Production: Some Historical Perspective

We can get an overview of the relationship of drilling activity and the energy production of oil and gas by looking at the historical data. The drilling activity numbers are from Baker Hughes Corporation data that tracks active rotary drill rigs in the United States from 1949 to present. Oil and gas production are Energy Information Administration (US Department of Energy) domestic production data.



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Simply from inspecting the nearly 60 years of data in Figure 1, five important facts become clear:

1. While there is currently much debate about the possible timing of a global peak in oil production, from a U.S. domestic point of view, peak oil is very old news: US oil production peaked in 1970. This peak has never been exceeded despite the subsequent 38 years of technological improvement, major events like the ramping up of Alaskan North Slope oil production, and the economic incentive of increasing oil prices in recent years.
2. After a similar initial 1970s peak, gas production has positively diverged from oil production, with gas recently setting new records. However, despite price increases and technological innovation, the rate of gas production has been in a near plateau for the last decade. Very recently, there is tantalizing, but as of yet still historically unimpressive, evidence of a recent surge in gas production.
3. Over this large time scale, there is remarkably little correlation at all between drilling activity and oil production. For example, from 1955 to 1970 drilling activity in the US decreased steadily, from over 2500 working rotary rigs all the way down to 1000. Yet during this time oil production *increased* by over 40% and gas production increased by 100%. In this period, the US domestic oil region was still relatively young, geologically speaking—with large and easily accessible fields readily available—rather than the mature, literally "over the hill", region it is today.
4. The best case one can make for the benefits of increased drilling is during the period from 1971 to 1981 when—spurred by the oil embargo, the huge price increase of oil, and Jimmy Carter's infamous cardigan—the number of active rotary drill rigs more than *quadrupled*. This Herculean increase in drilling activity did manage to reverse the decline in US oil production for several years (after a five year delay). Yet, despite the vastly increased drilling effort, oil production at the secondary peak was still *below* the 1970 peak. In fact, to take the most optimistic assessment of the benefits of drilling, the 300% increase in drilling bought just a 10% increase in oil production from the 1976 intermediate nadir to the secondary 1985 production peak. During this same period, gas production actually continued to fall for several more years.
5. Recently, the benefits of increased drilling in expanding oil production are even more anemic.

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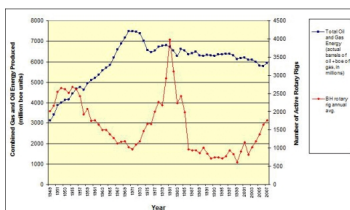
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With US domestic resources increasingly mature, the recent increase of drilling—a three-fold increase from 1999 to 2008—has not only brought no increase in oil production, it has not even stopped the continuing *decrease* in domestic oil production over the last decade. Gas production, however, has modestly increased over the last twenty years but, viewed macroscopically, this increase has been largely statistically uncorrelated with variation in drilling effort.

The Energy Return on Drilling

Oil has unique strategic importance as a dense, easily moved fuel—particularly essential for fueling modern transportation—and because of this oil deserves particular focus. But energy is, ultimately, fungible (in practice, often at some cost in efficiency). Therefore, for determining the long-term strategic value of increased drilling effort, the paramount functional relationship is the total energy produced from drilling activity in the United States. With gas production measured in equivalent energy units (boe) as a barrel of oil, total energy produced from both gas and oil is a simple sum.



It is obvious from this graph that, for nearly four decades now, the total US energy production from domestic oil and gas has been in steady overall decline. Especially surprising is the fact that the enormous spike in drilling effort in the 1970s and early 1980s had essentially no apparent effect on US energy production. The modest increase in gas production in the last two decades has been more than cancelled out by the decrease in oil production, in energetic terms. To anyone tempted to join a populist chorus of "Drill, baby, drill!" this is an especially

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sobering graph.

Why is There Essentially No Correlation Between Drilling and Energy Production?

We must be clear: drilling is certainly an essential stage in oil and gas exploration and production. In fact, continued drilling is absolutely essential to continued oil and gas production. For typical wells, production begins to decline soon after pumping begins. The situation is rather like Lewis Carroll's Red Queen, it takes considerable effort just to stay in the same place, in terms of production. But why, then, is there essentially no apparent energy return on increased drilling in the US historical data in the last half century?

The reason is that in a significantly depleted, "mature" petroleum region like the United States, there are severely diminishing returns on increased drilling effort. Why this is the case is really quite simple: petroleum geologists, apparently, know their business. For a nonrenewable resource, a relationship of severely diminishing returns is exactly the relationship expected if geologists are generally able to prioritize the exploitation of both new and existing reserves. In times of low energy prices, the base rate of drilling is low, but it is concentrated on the best prospects, and so the return on drilling effort is greater. In contrast, when high prices encourage more drilling, they generally open up relatively small, inaccessible, and otherwise marginal reserves and, because of this, increased drilling has remarkably little effect on the regional production numbers. This means that, for a significantly depleted region like the United States, increased drilling has very little impact at all on the strategic energy picture.

Quantitative Analysis of the Diminishing Energy Return of Increased Drilling Effort

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We can analyze US oil and gas drilling and subsequent energy production more closely and quantitatively by graphing the relationship of the number of working drill rigs in a year, and the domestic energy production from oil and gas *per rig*.

In this analysis, a five year time delay to account for the time from drilling activity to resulting production is used. Oil and gas are not produced immediately from new wells. The delay from drilling to production ranges from a very short delay, for production-expansion wells from known fields, to a very long delay, for exploration wells in inaccessible and unexplored petroleum regions. The choice of a five year delay is empirically driven: five years is the best fit delay from the data on drilling and oil production for the US (there is actually no macroscopic relationship apparent at all in the data for US gas production). The graphs therefore depict the relationship between drilling at time t (year 2000 for example) and the energy production at time $t+5$ (year 2005 for example).

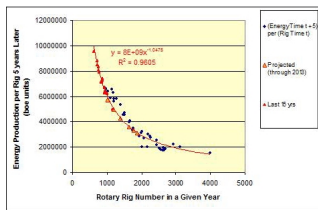


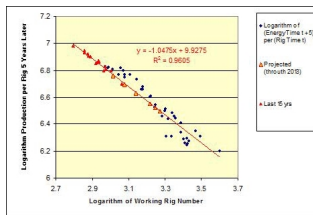
Figure 3 is quite an extraordinary graph—and a sobering one. Unlike the loose overall historical relationship between domestic drilling and production, there is quite a tight relationship between drilling activity and subsequent oil and gas energy production per rig. The relationship, however, is precisely the last one you would want if you hope that drilling will solve the United States' energy problems. The relationship shows that more active drill rig translates quantitatively into less energy per rig. Even worse, as the red data and fitted curve show, this law of diminishing returns has become, if anything, statistically tighter during the increase in drilling over the 15 years.

The relationship is a power law, and the negative exponent characterizes the diminishing returns on increased drilling effort. The fact that the exponent is less than negative one indicates that the returns on increased drilling are *severely diminishing*. The simplicity of the relationship is easier to see on a logarithmic graph, which "takes all the curves out" of a power

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relationship like this, and depicts it in linear form (Figure 4).



These two graphs (Figures 3 and 4) make plain the severely diminishing returns on increased drilling effort in the United States. Any attempt to determine the strategic effects of increased drilling must take these relationships into account. These facts are not at all congenial for anyone who hopes that the US can drill its way to energy independence. However, for strategic policy making, the fundamental simplicity and the considerable statistical strength of the diminishing return relationship makes quantitative prediction of energy production from drilling quite robust and tractable, macroscopically.

The Optimist's View - Could We Be In a New Era?

From the historical data, there is essentially zero evidence to suggest that even a very large increase in domestic drilling will bring substantially increased energy returns. The United States is unlikely to ever gain enough new domestic energy supplies from ramping up drilling to significantly change its dependence on imported energy; not at current rates of consumption.

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But there is an optimistic view that, to play devil's advocate, is at least worth characterizing. This optimistic view does, however, depend on the usually unjustified assumption that we are in a new era, where previous constraints no longer apply. This "new era" argument rests on the notion that technological advances like widespread horizontal (and other directional) drilling, deepwater gas production techniques, and other advances in oil and gas recovery—all of which can make formerly uneconomic gas reserves profitably recoverable—have substantially changed the rules of the game. There is a cultural element to this putative "new era" in the oil patch. The exploration and production industry may have finally stopped viewing gas as the ugly stepsister of oil. There has been a long preference in the industry for oil over gas. In fact, for a long time gas was a sign of disappointment: it was mostly a worthless waste product to be flared off, or a sign that you had drilled in the wrong place, outside the geological "oil window." Natural gas is a less energy-dense product, and it requires a lot of expensive plumbing to collect it, move it around, and bring it to market. The necessary infrastructure to market gas, and the economies of scale that go along with this, mean that gas is especially unappealing for the smaller and more entrepreneurial operations that respond the quickest to price increases. This may be why the 1980s drilling spike led to a real secondary peak in oil production which was real, if anemic, but at the same time gas production actually languished. The drilling spike of the early 1980s seems to have been diversionary in an important sense: it prompted a temporary interruption in the gradual shift from oil to gas that was already occurring in the US. For a short time, the good old days in the oil patch were back, and the active pursuit of gas took the backseat while high prices lasted. There is a social, even psychological, aspect to this as well: saying "I'm a oil man," has a different ring to it than saying "I'm a gas man," although, as gas continues to displace oil in importance domestically, that may certainly change.

So part of the "new era" argument rests on the idea that the US oil and gas industry realizes things have really changed, and has now appropriately focused much of current drilling and infrastructure development squarely on natural gas. With technological improvements like horizontal drilling and coalfield gas recovery, one can optimistically argue that a new peak in energy resources from the drill bit may be in the offing. Such arguments have been made before, but it is not impossible *a priori* that such a "new era" might this time be real. The truth will be known in the next 2-3 years. If the slight increase in domestic energy production from gas and oil in 2007 and 2008 turns into a substantial and sustained increase in total energy supplies, it will mean that such a new era is real. However, even if this unlikely and unprecedented possibility becomes a reality, the United States would do well to learn from its experience with oil. Domestic production of oil peaked nearly 40 years ago, and there is virtually no chance of ever again matching 1970 levels of production, much less exceeding them. In the unlikely event that a sustained secondary gas production peak ensues, the US would be wise to remember that this peak will be finite, and to consider allocating a significant portion of this energy towards the development of truly sustainable domestic energy supplies.

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Conclusions

The macro relationship of drilling and energy production is quite clear, and can be summarized in three main points:

1. There is very little chance that even a great increase in drilling will significantly increase US domestic oil production. Given the extraordinary strategic and economic importance of oil, this a critically important point.
2. There is more hope for natural gas, with production likely to continue increasing for some time. However, unless you are a true believer that we are in a completely "new era", the statistical relationship of diminishing returns on increased drilling activity is likely to also sharply constrain the gains possible in the domestic production of gas. Whatever your optimism level regarding drilling, it is a robust conclusion that any significant increase in domestic energy supplies from drilling—or perhaps, more realistically, any deceleration of the rate of decline of domestic energy supplies from oil and gas that we have seen for nearly four decades—is likely to be dominated by the production of natural gas, far more than oil.
3. The reason for the diminishing returns on drilling effort is that *the geologists know their business* . Historically, the overall energy we gain from domestic drilling has shown essentially no response to increased drilling effort. This is because periods of high drilling activity generally open only marginal resources that do surprisingly little to increase overall national production.

These three points, which follow from a macroscopic look at drilling and production data, are important to keep in mind—for government policy makers, corporations, and investors—when deciding how to allocate capital for future energy needs.

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Epilogue: The Energy Debt—Game Theoretic Considerations of Depleting Nonrenewable Resources

The fact that increased drilling is unlikely to substantially change the strategic picture of domestic energy production in the United States has an important implication. It means that more weight must be given to the *strategic costs* of ramping up the exploitation of the remaining US resources. There is a tradeoff in oil and gas production that, before now, has too often been ignored. The focus is always on the benefit of increased drilling—at this point at best a small increase in domestic energy production—but there is an unavoidable, associated future strategic cost to the exploitation of any nonrenewable resource. This future strategic cost is often neglected in policy considerations. With nonrenewable resources like oil and gas, being more "energy independent" now necessarily implies increasing energy *dependence*

at some point in the future. In a region as geologically "mature" as the United States, with only a very small fraction of the world's remaining petroleum reserves, increasing current production will also decrease the future strategic options for US energy policy. If this game is played without foresight, it will only hasten the day when oil-rich regimes in the Middle East are the only players at the table with any chips left. Because of the extreme short-sightedness of most political considerations, this inescapable tradeoff is all too often completely ignored strategically. By focusing on the short term benefits of nonrenewable resource exploitation, while neglecting the future costs of depletion, a nation engages in a form of deficit spending. Like other national debts, the energy debt can be overlooked, ignored, and denied, even for generations, but the account *will* eventually be settled.

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