# Executive Summary

This study was undertaken by the Energy Information Administration (EIA) at the request of the Principal Deputy Assistant Secretary for Fossil Energy of the Department of Energy. The request followed a letter to Secretary of Energy Bill Richardson from six trade organizations for oil and gas producers: the American Petroleum Institute, Domestic Petroleum Council, Independent Petroleum Association of America, U.S. Oil and Gas Association, National Ocean Industries Association, and Natural Gas Supply Association.

In their letter, the six organizations raised concerns about the effects of depletion on future oil and natural gas supply. Recent interest in the effects of depletion follows reports which suggest that future production may be more difficult than previously thought. Several reports have highlighted the sharp change in the decline rate for wells on the continental shelf in the Gulf of Mexico. While natural gas wells drilled in 1972 declined from their peak at an average rate of 17 percent per year, natural gas wells drilled in 1996 have been declining at an annual rate of 49 percent. At the same time, the ratio of natural gas production to the level of proved reserves—resources that have been identified and are ready to be developed—have increased from 15.7 percent in 1991-1992 to 18.0 percent in 1997-1998. In addition to the effects of depletion, exploratory drilling for oil and gas was also extremely low in 1999 as a result of unusually low prices. In 1999 the average number of rigs drilling for oil and natural gas was only 625, the lowest level in decades. Although the short-term effect of lower drilling activity already is being reversed as a result of higher prices for oil and gas in 2000, accurate future projections must account for the long-term effects of depletion on oil and gas production.

The projections of future oil and gas prices and production presented in EIA's *Annual Energy Outlook 2000* (*AEO2000*) are produced by the National Energy Modeling System (NEMS), which is designed to capture the expected impact of depletion on future production and prices, based on historical trends. Although the *AEO2000* projections incorporated the effects of depletion, this study develops a series of alternate scenarios that project more pronounced effects from depletion than suggested by the long-term historical trend. The scenarios described below show that changing the projected effects of depletion causes changes in projected U.S. oil and natural gas prices and production, as expected.

## Background

Depletion is a natural phenomenon that accompanies the development of all nonrenewable resources. Taken most broadly, depletion is a progressive reduction of the overall stock (or volume in the instance of oil and natural gas) of a resource over time as the resource is produced. In the oil and gas industry, depletion may also more narrowly refer to the decline of production associated with a particular well, reservoir, or field. As existing wells, reservoirs, and fields are depleted, new portions of the resource base must be tapped to replace those that can no longer be produced at economical levels.

Oil and natural gas fields vary in both size and ease of development. In general, the first fields developed from the resource base in a given geographic area are relatively large and accessible. Subsequent fields in the same area are on average smaller, may be more costly to develop, and may not allow the same level of production as the fields they are replacing. Thus, as time progresses, more effort is required to produce the same amount of oil and gas from the same exploration area. Historically, this trend has been counterbalanced by a trend of increasing initial production from oil and gas wells, made possible by advances in drilling technology. On the other hand, higher initial production rates have also been accompanied by more rapid declines in the later stages of production. As a result, more exploration and development activity is needed to maintain production levels. If drilling does not increase, production will inexorably fall; but if drilling increases sufficiently, production can actually increase despite the finding of smaller and potentially less productive fields.

In addition to technology advances, the periodic opening of entire new areas to exploration and development has balanced the effects of resource depletion in the past. While a myriad of technological improvements have allowed oil and gas resources to be discovered more efficiently and developed less expensively and have extended the economic life of existing fields, declines in the available resources in traditional oil and gas producing areas have led to development of oil and gas resources in such "frontier" areas as Alaska and the deep waters of the Gulf of Mexico.

## Methodology

In NEMS, the effects of resource depletion, technology advances, and access to new resources on oil and gas production are modeled in the Oil and Gas Supply Module (OGSM).[1] For this analysis, NEMS was used to generate a series of projections based on different assumptions about the effects of depletion on future production and prices. Sensitivity cases were developed to evaluate the effects on changes resulting from accelerated depletion of U.S. oil and gas resources that might result from higher imports of natural gas, higher or lower world oil prices, different rates of improvement in technology, and increased access to unconventional natural gas resources in the Rocky Mountains. A total of 12 cases were examined. The assumptions used to define the Reference Case, the Accelerated Depletion Case, and all but one of the sensitivity cases were provided by the Office of Fossil Energy, in consultation with representatives of the six trade groups requesting the study. Appendix A includes a description of the cases provided by industry representatives and the Office of Fossil Energy.

- **Reference Case.** The Reference Case, depicting business as usual, is similar to the Reference Case for the *Annual Energy Outlook 2000* (*AEO2000*), with some minor changes in the assumed conventional natural gas resource base in the Rocky Mountain region and the technology assumptions for unconventional gas production. The world oil price and natural gas wellhead prices in 1999 and 2000 were also revised to be consistent with short-term projections from EIA's April 2000 *Short-Term Energy Outlook*[2] (see Appendix E for more detail).
- **Accelerated Depletion.** The Accelerated Depletion Case, reflecting the issues raised by the six trade groups, shows a faster decline in production than the Reference Case. Future oil and gas discoveries are assumed to be one-third smaller and new fields are projected to produce more rapidly than in the Reference Case. Assumptions about the rate of technological change and accessible oil and gas resources are the same as in the Reference Case. The Accelerated Depletion Case is a hypothetical case designed to highlight the potential impacts of lower reserve additions and faster depletion rates on natural gas and oil prices, production, imports, and consumption.
- **Accelerated Depletion with High and Low World Oil Prices**. These two cases show how domestic production and prices with accelerated depletion are affected by different world oil price paths. The high and low oil price cases are the same as those used in *AEO2000*. The High World Oil Price Case assumes that the world oil price rises to $28.04 per barrel in 2020, compared with $22.90 in the Reference Case and $14.90 in the Low World Oil Price Case (all prices in 1998 dollars).
- **Accelerated Depletion with Rapid and Slow Technology Growth.** These two cases show the interaction of accelerated depletion with changes in the expected rate of technological development. The rate of technological improvement is captured by changes in future costs, drilling accuracy, and the amount of oil and gas added to proved reserves with each well drilled. For conventional oil and natural gas, NEMS uses a composite rate of technology growth and does not project the introduction of specific technologies. The rate of technological growth used in the Reference Case is based on past trends. In the Rapid Technology Growth Case, technology advances are assumed to increase the rates of improvement in costs, accuracy, and reserve additions per well by 50 percent over those in the Reference Case; in the Slow Technology Growth Case, the improvement rates are assumed to be 50 percent slower.[3] While the fields found in the Accelerated Depletion Cases are smaller than those found in the Reference Case, changing the technology influences how quickly and thoroughly these fields are developed. Rapid technology growth causes the projected volume of reserve additions per well to be higher than the Accelerated Depletion Case over time and closer to the path set in the Reference Case; in other words, faster technology growth can partially offset depletion effects. Slower than expected technology growth causes projected volumes of reserve additions to be lower than the Accelerated Depletion Case, or make depletion effects worse. All other parameter values are the same as in the Reference Case, including the technology parameters for other modules, parameters affecting foreign oil supply, and assumptions about imports and exports of liquefied natural gas and natural gas trade with Canada and Mexico. The path of the world oil price is the same as in the Reference Case.

[1]NEMS is an integrated model that balances supply and demand for each fuel and consuming sector on an annual basis. A synopsis of NEMS, the model components, and the interrelationships between the components is available in Energy Information Administration, *The National Energy Modeling System: An Overview*, DOE/EIA-0581(2000) (Washington, DC, March 2000).

[2]Energy Information Administration, *Short-Term Energy Outlook*, DOE/EIA-0202(00/2Q) (Washington, DC, April 2000), www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr00.pdf.

[3]Although the Rapid and Slow Technology Growth Cases are designed to highlight the uncertainty associated with the effects of technological development, they do not provide a formal confidence interval. In *AEO2000*, the rates of technological growth for the technological sensitivity cases were adjusted by 33 percent, rather than the 50 percent used for this analysis in order to acknowledge the broad range of uncertainty around future technological change.

- **Accelerated Depletion with Improved and Reduced Productivity Technology.** Changes in reserve additions per well have a greater effect on prices and production than do changes resulting from other types of technological change. In these two cases, the effect of technology improvement is captured only for changes in reserve additions per well drilled, without changing assumptions about future costs or drilling accuracy. Therefore, the projections from the Improved and Reduced Productivity Technology Cases vary less from the Reference Case projections than do those from the Rapid and Slow Technology Cases. Nevertheless, the Improved and Reduced Productivity Technology Cases capture most of the effects of the broader cases, in which all technology rates are adjusted. In the Improved and Reduced Productivity Technology Cases, the rate of growth in the amount of oil and natural gas added to proved reserves per well is adjusted by plus or minus 50 percent. Other rates of technological change are the same as in the Reference Case. The path of the world oil price is also the same as in the Reference Case.
- **Accelerated Depletion with High Rocky Mountain Access.** This case illustrates the effects of increasing the amount of natural gas available for development in the Rocky Mountain States by assuming the elimination of environmental and other constraints on production in the region. The question of access is limited to the Rocky Mountain region, where resources are sizable. In the Reference Case, 97 trillion cubic feet out of a total of 251 trillion cubic feet of unconventional gas resources is assumed not to be accessible to development before 2020. In the High Rocky Mountain Access Case, the inaccessible portion is assumed to be only 18 trillion cubic feet. The world oil price path is the same as in the reference case.
- **Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology.** This case combines the assumptions of the two previous cases to show how increased Rocky Mountain access and improved productivity technology could ameliorate the effects of accelerated depletion.
- **Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Growth.** This case combines the assumptions of the Rapid Technology Growth and High Rocky Mountain Access Cases to show how increased access and faster technology growth could offset some of the effects of declining production due to accelerated depletion.

In addition to the 11 cases provided by the Office of Fossil Energy, one other case was developed to address the uncertainty regarding the potential for additional imports of natural gas, primarily from Canada and Mexico:

- **Accelerated Depletion with High Natural Gas Imports.** This case combines the assumptions of the Accelerated Depletion Case with an assumed increase in the volume of natural gas imported from other countries. In the Accelerated Depletion Case, despite higher price projections, pipeline imports of natural gas from Canada are limited by constraints on pipeline capacity, and imports of liquefied natural gas (LNG) are limited by constraints on gasification plant capacity. In this case, more natural gas imports and a more rapid increase in imports are allowed in response to the higher domestic prices that result from accelerated depletion than are allowed in the Reference and Accelerated Depletion Cases. Other assumptions about world oil prices, technology growth, and access to Rocky Mountain resources are the same as in the Reference Case.

## Summary of Results

### *Accelerated Depletion Leads to Higher Prices and Lower Production than in the Reference Case, with the Greatest Differences in the Later Years of the Projections*

The Accelerated Depletion Case assumes that each new well developed in the future will add less to U.S. oil and gas reserves than assumed in the Reference Case. As the projections progress, adding oil and gas reserves becomes increasingly more difficult in the Accelerated Depletion Case than in the Reference Case, and the oil and gas reserves available for production are increasingly lower than in the Reference Case. Newly added reserves in the Accelerated Depletion Case are assumed to be produced more intensively than in the Reference Case (that is, the ratio of production to reserves for new additions is higher), but the cumulative effect of smaller reserve additions is a lower overall level of production for both oil and natural gas (Table ES1 and Figures ES1 and ES2). By 2020, natural gas production in the lower 48 States is projected to be 22.5 trillion cubic feet, 13 percent lower than the 26 trillion cubic feet per year projected in the Reference Case. Lower 48 crude production in 2020 is projected to be 4.7 million barrels per day, compared with 5.0 million barrels per day in the reference case. The difference in projected production levels between the two cases is more pronounced for natural gas than for oil because of the difference in the two fuel markets.

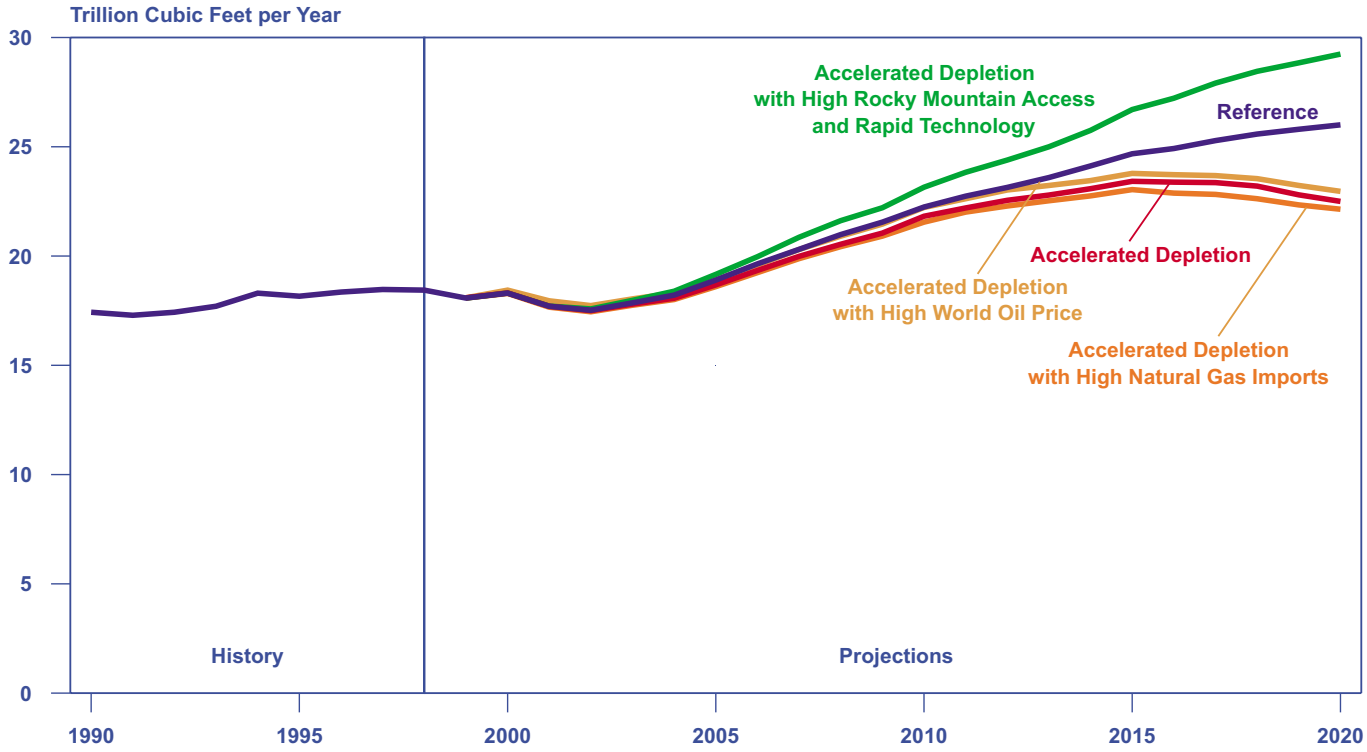
In the U.S. natural gas market, prices are determined largely by the domestic supply and demand balance. Unlike oil, there is not a corresponding world price for natural gas, because of the differences in infrastructures which connect producers to consumers. Tighter supply

## Table ES1. Projected Lower 48 Crude Oil and Natural Gas Production in Twelve Cases, 2005-2020

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Reference | 18.9 | 22.2 | 24.7 | 26.0 |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| Accelerated Depletion with High Natural Gas Imports | 18.6 | 21.6 | 23.0 | 22.1 |
| Accelerated Depletion with High World Oil Price | 18.9 | 22.2 | 23.8 | 23.0 |
| Accelerated Depletion with Low World Oil Price | 18.6 | 21.7 | 22.9 | 21.9 |
| Accelerated Depletion with Rapid Technology | 19.2 | 23.2 | 26.3 | 28.4 |
| Accelerated Depletion with Slow Technology | 18.4 | 21.0 | 21.9 | 20.3 |
| Accelerated Depletion with Improved Productivity Technology | 19.0 | 22.8 | 25.2 | 25.8 |
| Accelerated Depletion with Reduced Productivity Technology | 18.6 | 21.6 | 22.8 | 21.9 |
| Accelerated Depletion with High Rocky Mountain Access | 18.7 | 22.0 | 23.8 | 23.2 |
| Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology | 19.0 | 22.9 | 25.5 | 26.4 |
| Accelerated Depletion with High Rocky Mountain Access and Rapid Technology | 19.2 | 23.2 | 26.7 | 29.2 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Reference | 4.3 | 4.5 | 4.8 | 5.0 |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with High Natural Gas Imports | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with High World Oil Price | 4.5 | 4.5 | 4.9 | 5.3 |
| Accelerated Depletion with Low World Oil Price | 4.0 | 3.9 | 3.9 | 4.1 |
| Accelerated Depletion with Rapid Technology | 4.4 | 4.6 | 5.0 | 5.3 |
| Accelerated Depletion with Slow Technology | 4.1 | 4.0 | 4.0 | 4.0 |
| Accelerated Depletion with Improved Productivity Technology | 4.4 | 4.6 | 5.0 | 5.3 |
| Accelerated Depletion with Reduced Productivity Technology | 4.1 | 4.0 | 4.0 | 4.1 |
| Accelerated Depletion with High Rocky Mountain Access | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology | 4.4 | 4.6 | 5.0 | 5.3 |
| Accelerated Depletion with High Rocky Mountain Access and Rapid Technology | 4.4 | 4.6 | 5.0 | 5.3 |

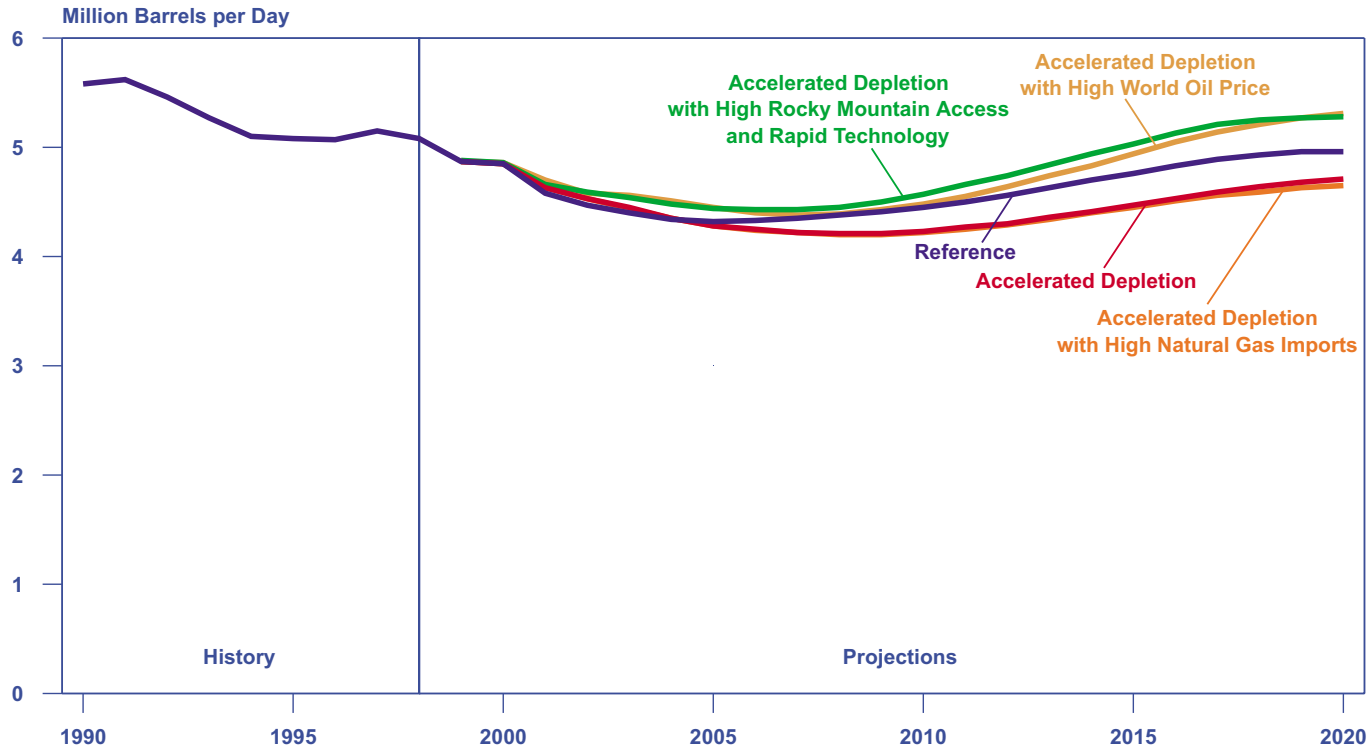
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, OGLWOP.D051200A, OGRTECH.D051200A, OGSLOW.D051200A, OGFRHTEC.D051200A, OGFRLTEC.D051200A, OGACCESS.D051200A, OGACCFR.D051200A, and OGRAPID.D051200A.

## Figure ES1. Lower 48 Natural Gas Production in Five Cases, 1990-2020



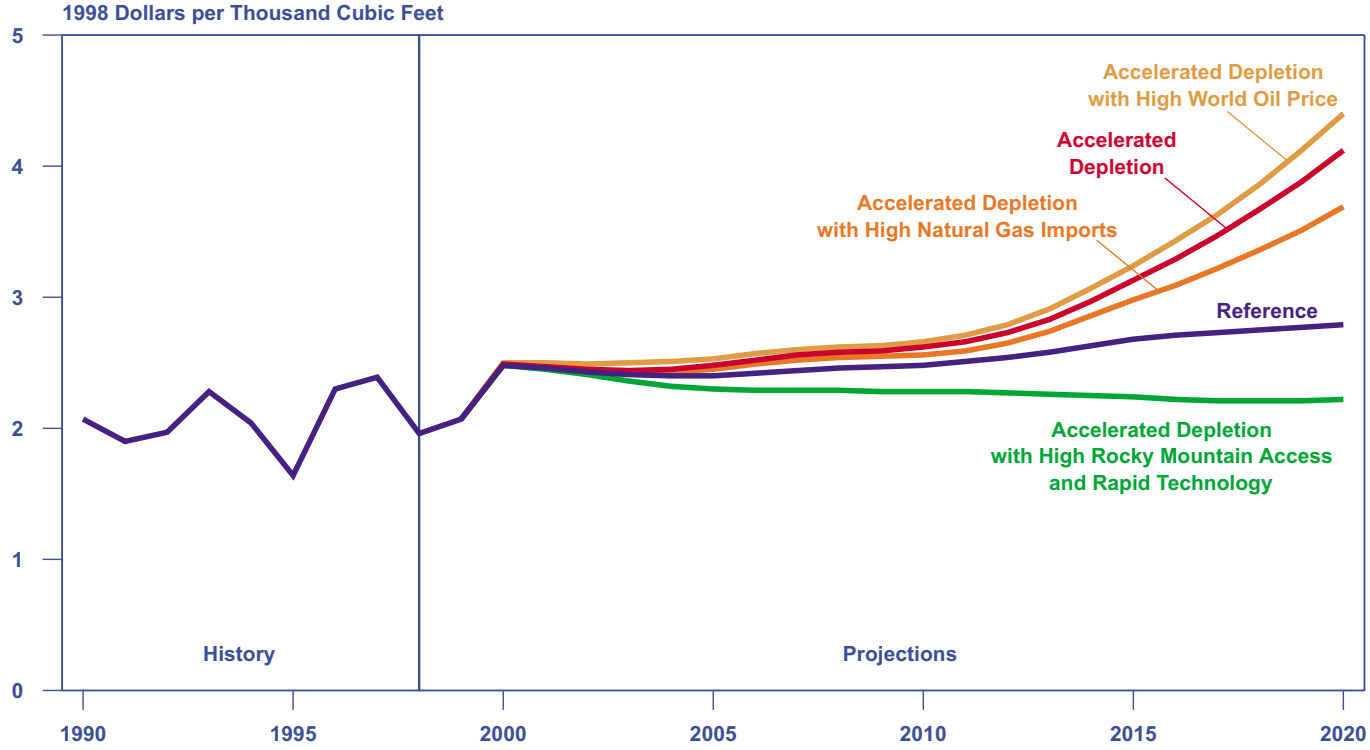

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, and OGRAPID.D051200A.

## Figure ES2. Lower 48 Crude Oil Production in Five Cases, 1990-2020




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, and OGRAPID.D051200A.

## Figure ES3. Lower 48 Natural Gas Wellhead Prices in Five Cases, 1990-2020




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, and OGRAPID.D051200A.

**Table ES2. Projected Lower 48 Average Natural Gas Wellhead Prices in Twelve Cases, 2005-2020**

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| (1998 Dollars per Thousand Cubic Feet) | | | | |
| Reference | 2.40 | 2.48 | 2.68 | 2.79 |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |
| Accelerated Depletion with High Natural Gas Imports | 2.45 | 2.56 | 2.98 | 3.69 |
| Accelerated Depletion with High World Oil Price | 2.53 | 2.66 | 3.24 | 4.40 |
| Accelerated Depletion with Low World Oil Price | 2.30 | 2.47 | 2.95 | 3.60 |
| Accelerated Depletion with Rapid Technology | 2.31 | 2.30 | 2.32 | 2.37 |
| Accelerated Depletion with Slow Technology | 2.57 | 2.83 | 3.59 | 4.56 |
| Accelerated Depletion with Improved Productivity Technology | 2.37 | 2.39 | 2.65 | 2.99 |
| Accelerated Depletion with Reduced Productivity Technology | 2.49 | 2.66 | 3.33 | 4.24 |
| Accelerated Depletion with High Rocky Mountain Access | 2.46 | 2.57 | 3.01 | 3.90 |
| Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology | 2.35 | 2.37 | 2.57 | 2.81 |
| Accelerated Depletion with High Rocky Mountain Access and Rapid Technology | 2.30 | 2.26 | 2.24 | 2.22 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, OGLWOP.D051200A, OGRTECH.D051200A, OGSLOW.D051200A, OGFRHTEC.D051200A, OGFRLTEC.D051200A, OGACCESS.D051200A, OGACCFR.D051200A, and OGRAPID.D051200A.

in the Accelerated Depletion Case causes both production and consumption projections to be lower than in the Reference Case, and wellhead prices are uniformly higher (Figure ES3). The difference in prices between the two cases increases over the 20 years of the forecast. By 2020, the lower 48 wellhead price of natural gas in the Accelerated Depletion Case is 48 percent higher than in the Reference Case: $4.12 per thousand cubic feet (in constant 1998 dollars), compared with $2.79 per thousand cubic feet (Table ES2). As a result, gas consumption in 2020 is projected to be about 9 percent lower in the Accelerated Depletion Case than in the Reference Case, as consumers either switch to other energy sources or consume less energy altogether.

In the U.S. oil market, the lower 48 wellhead price is determined largely by the world oil price. The lower 48 wellhead price of oil in the Accelerated Depletion Case is projected to be roughly the same as it is in the Reference Case, because world oil prices are not significantly affected by changes in U.S. production. Although domestic oil production is expected to be lower in the Accelerated Depletion Case, oil prices are not expected to rise, because there are ample available imports to meet domestic consumption.

Total energy use in the Accelerated Depletion Case is projected to be 119.8 quadrillion Btu in 2020, compared with 121.0 quadrillion Btu in the Reference Case. In addition to lower natural gas use, higher prices for natural gas in the Accelerated Depletion Case are expected to cause consumers to use more coal and oil than they do in the Reference Case. Projected coal consumption in 2020 is about 3 percent higher in the Accelerated Depletion Case than in the Reference Case, as coal penetrates the electricity generation market with slightly higher prices. The projected use of crude oil and petroleum products is also higher by about 2 percent because of higher natural gas prices. Net imports of crude oil and petroleum products in 2020 are projected to be 16.9 million barrels per day in the Accelerated Depletion Case, compared with 15.8 million barrels per day in the Reference Case, because projected oil consumption is higher and production of oil and natural gas plant liquids is lower.

### *Higher Natural Gas Imports Reduce Domestic Natural Gas Prices and Production from the Levels Projected in the Accelerated Depletion Case*

In the Accelerated Depletion with High Natural Gas Imports Case, several assumptions were changed to show how more imports could influence the projections in the Accelerated Depletion Case. Three changes were made to the Reference Case assumptions to show how higher projected prices in the Accelerated Depletion Case might increase imports of natural gas, and what effect the increase would have on the rest of the market. First, the total capacity for imports from Canada was increased. By 2020, pipeline capacity for gas imports from Canada was assumed to be 20 percent higher than in the Reference and Accelerated Depletion Cases. Second, it was assumed that Mexico would become a net exporter of gas to the United States, rather than a net importer as in the Reference and Accelerated Depletion Cases, with higher prices stimulating an increase in Mexico's production of natural gas for export to the United States. In the Reference and Accelerated Depletion Cases, the United States is projected to export 200 billion cubic feet of gas to Mexico in 2020; however, in the Accelerated Depletion with High Natural Gas Imports Case, Mexico is projected to export 90 billion cubic feet per year to the United States in 2020. Third, U.S. imports of LNG in the Accelerated Depletion with High Natural Gas Imports Case are projected to increase to 450 billion cubic feet per year in 2020, compared with only 330 billion cubic feet in the Reference Case and 370 billion cubic feet in the Accelerated Depletion Case. Total U.S. imports of natural gas are projected to be 6.36

trillion cubic feet in 2020, compared with 5.52 trillion cubic feet in the Accelerated Depletion Case.

Higher imports lead to lower domestic prices for natural gas than are projected in the Accelerated Depletion Case, as more plentiful supplies allow consumers to buy more gas at lower prices. In the Accelerated Depletion with High Natural Gas Imports Case, the lower 48 wellhead price of natural gas in 2020 is projected to be $3.69 per million cubic feet—$0.90 higher than in the Reference Case but $0.43 lower than in the Accelerated Depletion Case. As a result, lower 48 production of natural gas is projected to be lower, at 22.1 trillion cubic feet per year in 2020, than in the Accelerated Depletion Case (22.5 trillion cubic feet in 2020). Because the change in assumptions is limited to imports of natural gas, the projected level of domestic oil production in the High Natural Gas Imports Case is nearly the same as in the Accelerated Depletion Case.

The assumptions for the Accelerated Depletion with High Natural Gas Imports Case do not extend the projected effects of accelerated depletion to either Mexican or Canadian resources. Although those resources are also subject to depletion, development of a methodology to introduce similar accelerated depletion assumptions into the Mexican and Canadian markets is beyond the scope of this analysis.

### World Oil Prices Influence Accelerated Depletion Results

The projected effects of accelerated depletion on U.S. wellhead prices and domestic production vary when higher or lower world oil prices are assumed. Higher oil prices lead to increased demand for natural gas as a substitute for oil, resulting in higher gas prices and higher domestic production. In the Accelerated Depletion with High World Oil Price Case, lower 48 gas production is projected to reach 23.0 trillion cubic feet in 2020—only about 0.5 trillion cubic feet higher than in the Accelerated Depletion Case and still 3.0 trillion cubic feet lower than in the Reference Case. At the same time, the natural gas wellhead price is projected to reach $4.40 per thousand cubic feet in the Accelerated Depletion with High World Oil Price Case, 28 cents higher than in the Accelerated Depletion Case, as higher oil prices induce fuel switching from oil to gas, causing demand and prices for natural gas to increase (Figure ES3).

Although total oil use is projected to be lower in the Accelerated Depletion with High World Oil Price Case than in the Accelerated Depletion Case because of higher prices, the same higher prices stimulate an increase in domestic oil production at the expense of imports. U.S. production reaches 5.3 million barrels per day in 2020, 0.6 million barrels per day higher than in the Accelerated Depletion Case and 0.3 million barrels per day above the Reference Case production level (Figure ES2). In contrast, natural gas production in the Accelerated Depletion with High World Oil Price Case is consistently lower than in the Reference Case, and in 2020 it is only slightly higher than in the Accelerated Depletion Case.

In the Accelerated Depletion with Low World Oil Price Case, demand for natural gas is lower than in the Accelerated Depletion Case, as consumers substitute oil for gas. The wellhead price of gas in 2020 is 52 cents per thousand cubic feet (13 percent) lower than in the Accelerated Depletion Case, and gas production in 2020 is 0.6 trillion cubic feet (3 percent) lower. Although more oil is consumed while prices are lower, the effect on oil production is a projected reduction of 0.6 million barrels per day from the 2020 production level in the Accelerated Depletion Case with reference prices. Lower production in the case with low oil prices is accompanied by higher imports to meet a higher level of demand for cheaper oil.

### Changes in the Rate of Technology Advances Influence the Results of Accelerated Depletion

In the Accelerated Depletion with Rapid Technology Case, faster innovation is expected to effectively counter many of the negative effects of depletion. Although new fields are smaller, technology allows new fields to be found more cheaply and developed more thoroughly at lower cost; thus, more oil and gas is available from U.S. fields each year at any given price. By 2020, the effects of increased potential production in the Accelerated Depletion with Rapid Technology Case cause the projected wellhead price of natural gas to be $1.75 per thousand cubic feet lower than in the Accelerated Depletion Case (Figure ES3), while natural gas production is projected to be nearly 6 trillion cubic feet per year higher in 2020. Oil production in 2020 is projected to be 0.6 million barrels per day higher in the Rapid Technology Case than in the Accelerated Depletion Case, as U.S. fields are able to produce more at the prevailing world price.

Focusing only on the effects of technology on reserve additions per well, the Accelerated Depletion with Improved Production Technology Case does not show as great an offset in the negative effects of accelerated depletion as does the more general Accelerated Depletion with Rapid Technology Case. However, unlike the Accelerated Depletion with Rapid Technology Case, natural gas production in the Improved Productivity Technology Case is projected to be lower than in the Reference Case in 2020, while oil production is projected to be higher (Table ES1). The natural gas wellhead price in the Rapid Depletion with Improved Productivity Technology Case is projected to be $2.99 per thousand cubic feet in 2020, more than a dollar lower than in the Accelerated Depletion Case with reference technology (Table ES2), and gas production in 2020 is projected to be 3.3 trillion cubic feet per year higher in 2020 than in the

Accelerated Depletion Case. Crude oil production in the Improved Productivity Technology Case is nearly the same as in the Rapid Technology Case in 2020.

Both the Accelerated Depletion with Reduced Productivity Technology and Accelerated Depletion with Slow Technology Cases project lower production and higher prices than those in the Accelerated Depletion Case, because less oil and gas is available for development. In the Accelerated Depletion with Slow Technology Case, the wellhead price of natural gas is projected at $4.56 per thousand cubic feet in 2020, about 11 percent higher than in the Accelerated Depletion Case; U.S. natural gas production in 2020 is projected to be 2.2 trillion cubic feet per year lower than in the Accelerated Depletion Case; and domestic oil production is projected to be 0.7 million barrels per day lower than in the Accelerated Depletion case.

### *Increasing Access to Rocky Mountain Lands May Partially Offset the Effects of Accelerated Depletion*

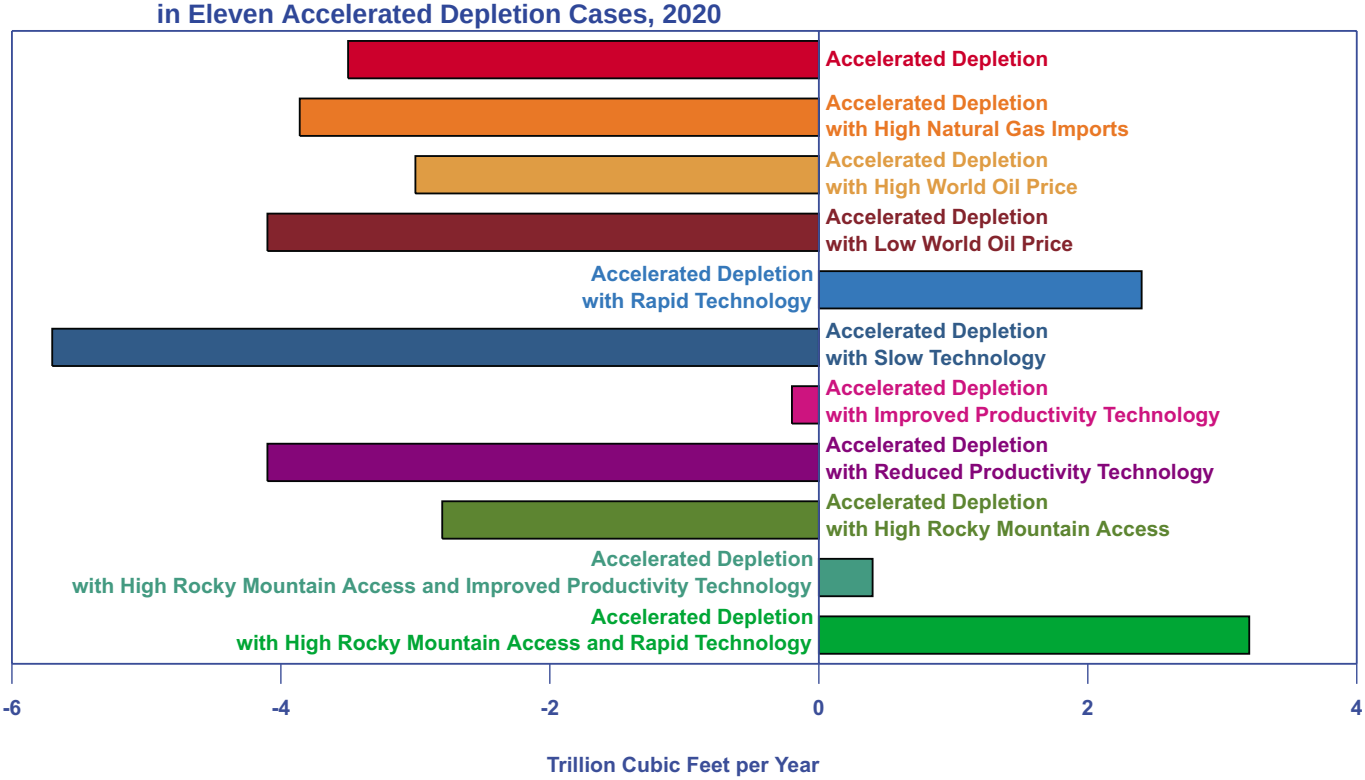
Increased access to natural gas resources on Federal lands in the Rocky Mountain region is projected to lead to higher natural gas production. Increased access would allow producers to develop unconventional gas resources that currently are off limits. In the Accelerated Depletion with High Rocky Mountain Access Case, lower 48 natural gas production in 2020 is projected to be 23.2 trillion cubic feet per year, or about 3 percent higher than in the Accelerated Depletion Case (Table ES1). The expected effect on national average wellhead prices is somewhat larger. Prices in the Accelerated Depletion with High Rocky Mountain Access Case in 2020 are projected to be about $0.22 per thousand cubic feet (5 percent) lower than in the Accelerated Depletion Case (Table ES2).

### *Combining Increased Access with Faster Introduction of Technology May Completely Offset the Effects of Accelerated Depletion*

The combination of faster development of technology and increased access to unconventional gas resources in the Rocky Mountains is expected to result in higher natural gas production at lower prices. Lower 48 natural gas prices in the Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Case are projected to be $2.22 per thousand cubic feet in 2020, and lower 48 natural gas production is projected to be 29.2 trillion cubic feet per year—compared with $4.12 per thousand cubic feet and 22.5 trillion cubic feet per year in the Accelerated Depletion Case (Tables ES1 and ES2). Indeed, the projected wellhead gas price in 2020 in the Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Case is 20 percent below the Reference Case projection (Figure ES3).

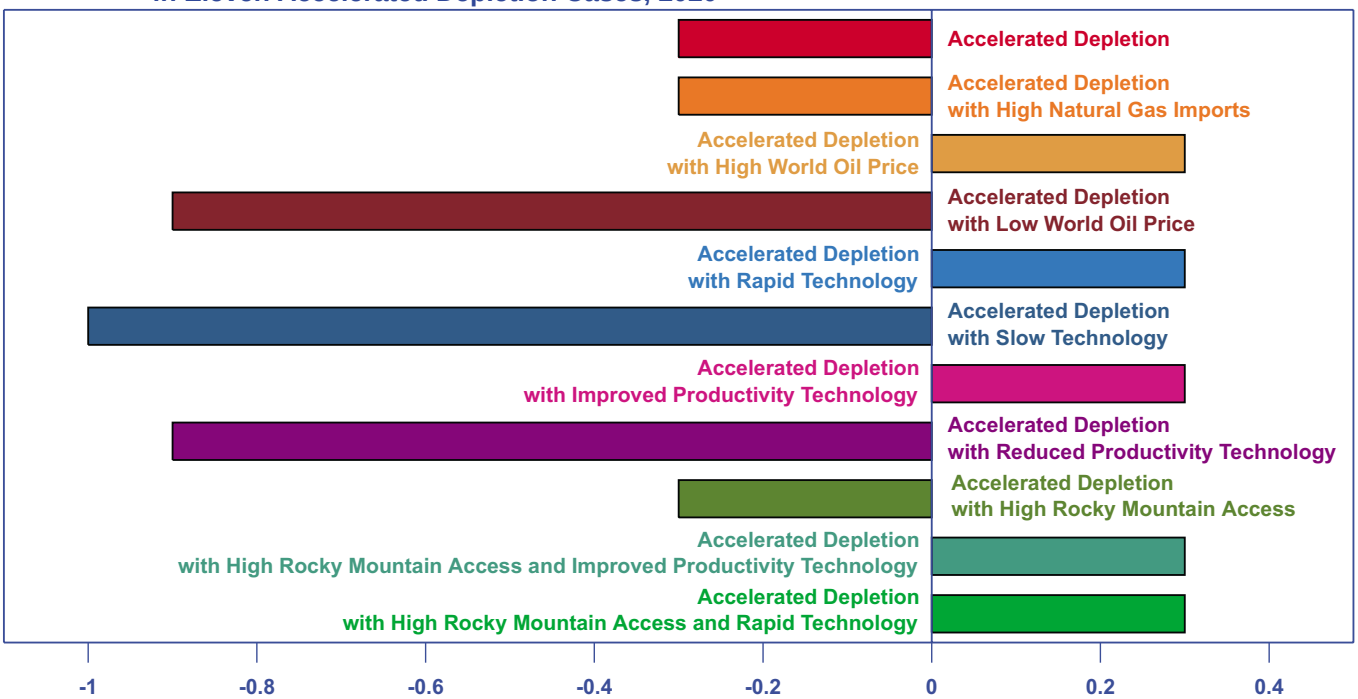
The differences between the Accelerated Depletion Case and the Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology Case are similar to those described above but less pronounced, because the improved productivity technology assumptions are more limited than the rapid technology assumptions. Natural gas prices and production in the Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology Case are projected to be roughly the same as in the Reference Case in 2020.

## Figure ES4. Differences from Reference Case Projections of Lower 48 Natural Gas Production in Eleven Accelerated Depletion Cases, 2020



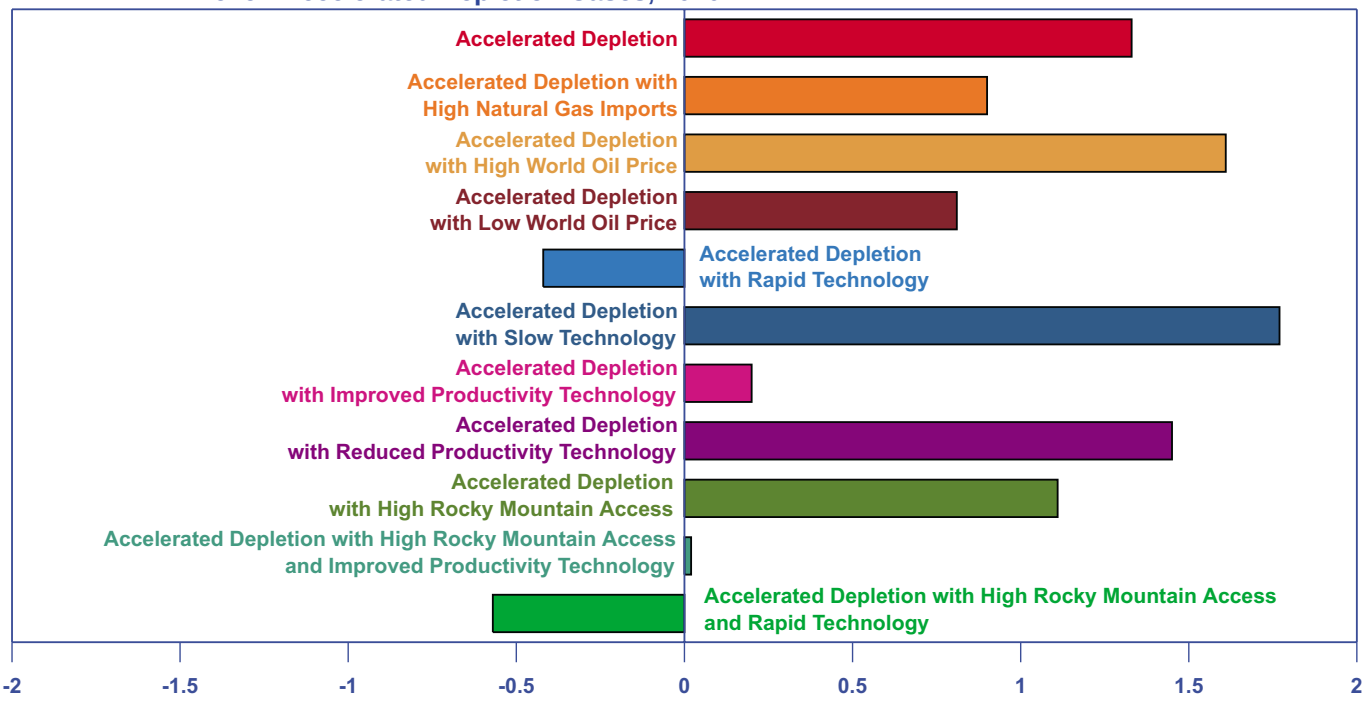

Sources: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, OGLWOP.D051200A, OGRTECH.D051200A, OGSLOW.D051200A, OGFRHTEC.D051200A, OGFRLTEC.D051200A, OGACCESS.D051200A, OGACCFR.D051200A, and OGRAPID.D051200A.

## Figure ES5. Differences from Reference Case Projections of Lower 48 Oil Production in Eleven Accelerated Depletion Cases, 2020




Sources: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, OGLWOP.D051200A, OGRTECH.D051200A, OGSLOW.D051200A, OGFRHTEC.D051200A, OGFRLTEC.D051200A, OGACCESS.D051200A, OGACCFR.D051200A, and OGRAPID.D051200A.

**Figure ES6. Differences from Reference Case Projections of Lower 48 Natural Gas Prices in Eleven Accelerated Depletion Cases, 2020**




Sources: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, DEPL2.D071700A, OGHWOP.D051200A, OGLWOP.D051200A, OGRTECH.D051200A, OGSLOW.D051200A, OGFRHTEC.D051200A, OGFRLTEC.D051200A, OGACCESS.D051200A, OGACCFR.D051200A, and OGRAPID.D051200A.

## Conclusions

The results of this analysis show how projections of future U.S. oil and gas prices and production are affected by changes in the assumptions made about the effects of resource depletion. As compared with the Reference Case for the analysis, the accelerated depletion assumption, by itself, leads to a lower projection for domestic natural gas production in 2020 (Figure ES4), a lower projection for domestic oil production (Figure ES5), and a higher projection for natural gas prices (Figure ES6). In addition, variations in assumptions about the future path of world oil prices, the availability of natural gas imports, the rate of technological innovation, and increased access to unconventional gas resources on Federal lands are shown to influence the projected effects of an assumed increase in the rate of resource depletion. Greater availability of natural gas imports is projected to moderate the price increase resulting from accelerated depletion and also to reduce lower 48 gas production relative to the projections in the Accelerated Depletion Case. Higher world oil prices are projected to raise production of both U.S. crude oil and natural gas in the Accelerated Depletion Case, although oil production is more sensitive to the world oil price than natural gas, due to the limits of substitutability between the two fuels. More rapid technology growth offsets the effects of accelerated depletion. Increased access to Rocky Mountain resources leads to more production of natural gas and lower prices.

When the effects of more rapid technology growth and increased access are considered together, production levels are projected to be higher than in the Reference Case. This result suggests that, for at least the next two decades, the potential negative effects arising in the event of accelerated depletion could be offset by an increase in the rate at which new technologies are introduced in the oil and gas industry and by a relaxation of current restrictions on drilling on Federal lands. While the accelerated depletion cases illustrate that depletion could increasingly affect U.S. oil and natural gas supplies in the decades to come, they should be considered as illustrative projections, not forecasts. If, in the future, the effects of resource depletion follow more closely the path laid out in the Accelerated Depletion Case than that in the Reference Case, it is likely that U.S. energy markets would be slightly more reliant on coal and imported oil.