Appendixes

Appendix A
Calculation of Additional Reserves From Increased Gas Recovery in Old Gasfields

OTA calculated the effects of higher gas prices on gas recovery in "old" gasfields by modifying a previous analysis of those effects conducted by the Shell Oil Co.[1] The OTA analysis is discussed in detail in a recent OTA staff memorandum and is summarized here.

The analysis focuses on the expansion of "old gas" reserves, which are defined here as all reserves that do not qualify for "new natural gas" status under the Natural Gas Policy Act (NGPA). In general, old gas is gas in reservoirs that were discovered (and reserves reported) prior to about mid-1977; however, the precise boundaries are more complicated than this.

Shell's Analysis

The Shell study assumed that all old gas would remain at low prices under the NGPA and would rise to $3.50/MMBtu, the assumed free market price, under a price decontrol policy. Shell calculated the effect of a $3.50 gas price on recovery in the Nation's old gasfields by the following method:

1. **Calculate the Nation's "responsive reserves," that** is, the old gas reserves that might grow if their prices go up. Some reserves, such as Alaskan North Slope gas, gas dissolved in oil, and, to a lesser extent, gas in water-drive reservoirs will not respond much to a gas price increase and were not included in the analysis of reserve growth. For example, gas dissolved in oil is responsive primarily to **oil** prices, because the value of the oil in the reservoir far outweighs the value of the gas. If oil prices go up, more oil will be produced and thus more gas will be co-produced with it.

Shell's estimate of responsive reserves in 1981: 115 TCF.

2. **Calculate reserve growth in sample fields** where adequate data are available. Shell evaluated the effects of a price increase to $3.50 on lower abandonment pressures and well reworkings, infill drilling, and well stimulation for 14 large sample fields. The lower abandonment pressure calculation involves computing the gas flow that will produce revenues equal to operating costs[3] for the new and old gas prices. The difference in reservoir pressures corresponding to the "new" and "old" flows, and the additional reserves corresponding to this pressure difference can then be calculated by using the physical gas laws. The infill drilling calculations were made using reservoir simulation and extrapolation from previous infilling experience. The well stimulation calculations are based on an engineering judgment that an additional 1.5 percent can be added to ultimate recovery by this means:

Reserves remaining in sample fields . . . . 41.3 TCF
Reserve growth, lower abandonment pressures and well reworking . 9.6 TCF
Reserve growth, infill drilling ... ., ... 7.6 TCF
Reserve growth, well stimulations = 1.5 percent of ultlmate recovery[4]

3. **Scale up the sample results to the Nation,** assuming that, except for well stimulations, the results will scale by the ratio of the remaining reserves:

Scaling factor = 11 5/41.3 = 2.8
National reserve growth for lower abandonment pressures and well reworkings = 9.6 X 2.8 = 27 TCF
National reserve growth for infill drilling = *7.6 X 2.8 = 21* TCF

By examining available production records and estimates of remaining reserves, Shell estimated that the ultimate recovery represented by the 115 TCF of responsive reserves is **475** TCF, thus:

National reserve growth for well stimulation = 0.015 x 475 = 7 TCF

Assuming that 3 TCF of the infill drilling would occur anyway at presently available prices (an incentive price of $2.75/MMBtu in mid-1983),

Total national reserve growth due to higher prices = 27 + 21 + 7 – 3 = 52 TCF

OTA's Modifications to Shell's Analysis

OTA has made a number of modifications to Shell's original calculations based on a detailed review of Shell's methodology, an evaluation of alternative data sources, a review of literature on infill drilling and other topics related to gas recovery, and a number of telephone interviews with geologists and petroleum engineers. The most important of the modifications are:

1. **Scaling to the Nation. OTA** determined that an appropriate scaling factor should be related as closely as possible to the original volume of gas in the fields. The basis of Shell's scaling factor, remaining reserves, is tied closely to the production history of the fields.

[1] C S Matthews, *Increase in United States "old" Gas Reserves Due to Deregulation,* Shell 011 Co , April 1983

[2] Office of Technology Assessment, *Staff' Memorandum on the Effects of Decontrol on Old Gas Recovery,* February 1984

[3] This is approximately the abandonment point for the well, 51 nce profits are zero at this point

[4] Ultimate recovery = cum u lativ e production plus remain ingreserves

Ultimate recovery, on the other hand, is more directly related to the original gas volume and is a more appropriate basis for the scaling factor. Using Shell's own calculations, the use of ultimate recovery as the basis for the scaling factor yields an increase in the expected national reserve growth of 36 percent (all else being equal).

2. **Responsive reserves. As noted above, Shell assumed that all old gas would remain at low prices under the NGPA, so that, for the calculation of responsive reserves,** Shell estimated the **total** old gas reserves and subtracted only those reserves that would be physically unresponsive to higher prices. However, the NGPA provides for the decontrol or price escalation of most old intrastate reserves by 1985, and the decontrol by 1985 or 1987 (depending on depth) of all gas from infill wells in old intrastate fields. Consequently, these reserves will receive a high decontrolled price whether or not any additional decontrol measure is passed, and thus are not "responsive" to such a measure . . . . they should be subtracted from Shell's calculated responsive reserves. Shell also made some minor errors in its original calculation of total old gas reserves; it treated all "extensions" added to reserves since 1977 as old gas, whereas some of these reserves qualify as "new" NGPA Section 102 gas and should have been excluded from the calculated total of old gas reserves.

Data on the amount of reserves in each NGPA category are not available. OTA used data on reserve volumes in interstate and intrastate commerce, interstate pipeline purchases by NGPA category, and limited production data by NGPA category to estimate the volume of old gas reserves in each category, and the volume of responsive reserves. Our estimate of responsive reserves was 63.4 to 71.4 TCF for lower abandonment pressures and well stimulations, and 59 to 66 TCF for infill drilling, as compared to Shell's 115 TCF estimate for each category. Consequently, all else being equal, Shell's results are overstated by the ratio of "incorrect" to "correct" reserves, or by a factor of about 1.6 to 2.0.

3. **Abandonment pressures. Shell's estimates of the current abandonment pressures** in its sample fields generally are considerably higher than the estimates of alternative analysts, for example, the American Gas Association's Committee on Natural Gas Reserves. A higher current abandonment pressure implies a larger growth potential, so applying the alternative, lower pressures would yield a lower estimate of the additional reserves available from the growth of older fields. Specifically, applying the alternative pressure estimates in those fields where such estimates are available more than halves the estimates of growth potential, from 8.1 TCF to 3.0 TCF. The uncertainty associated with these alternative abandonment pressure estimates was factored into OTA's estimates of field growth potential.

4. Infill drilling. A key point of contention with Shell's analysis of infill drilling is the extent to which the potential reserves may be available at today's prices without any legislative changes. Shell's prediction that only 3 TCF of a 21 TCF potential would be forthcoming at today's prices is based partly on its assumption that the low level of infill drilling activity of the past few years must reflect a lack of economic prospects. However, a variety of factors other than an inadequate price may have played a role in the current inactivity. These factors include the current gas surplus, opposition by pipelines or consumers, s opposition by other producers in the same field,[6] and State prorationing rules that prevent producers from increasing production rates. OTA's discussions with producers have lead us to believe that more than 3 TCF of the total infill potential would eventually be drilled at current prices. The range of infill potential in Scenario 1 reflects the possibility that as much as one-third of Shell's "after decontrol" infill potential could occur eventually without any further legislative change.

[5]Because the current infill Incentive price of about $2 .85/MMBtu applies to all gas from the infill well, Including gas that could have been produced from adjacent wells at a lower price.

[6]Because the potential for drainage across the field means that the other producers would have to infill also or face the loss of some of their gas.