Chapter 1

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INTRODUCTION

Within the last 5 years or so, the general perception about the outlook for future U.S. gas supplies has moved from pessimism to considerable optimism. The pessimism was based partly on short-term problems, such as periodic regional shortages, and partly on disturbing long-term trends, such as the declining finding rate for new gasfields and, since the late 1960's, the ominous and apparently unstoppable decline of proved reserves. The new optimism is based on several factors, including the gas "bubble" caused by declining gas demand coupled with high gas deliverability, the rebound of reserve additions to levels which exceeded production in 1978 and *1981*, and continuing optimistic estimates 01" domestic gas resources by the U.S. Geological Survey (USGS) and the industry-based Potential Gas Committee (PGC).

What does this apparent change in the outlook for U.S. natural gas supply mean? Can we now count on natural gas to play a major, perhaps even expanded role in satisfying U.S. energy requirements, or is the seeming turnabout only a temporary respite from a continuing decline in gas reserve levels and, soon to follow, a decline in gas production capabilities?

This technical memorandum presents the first phase of OTA's assessment of these questions: an evaluation of the future prospects for the discovery and production of conventional natural gas in the Lower 48 States. The memorandum examines the gas resource base and future production potential under the following conditions:

- wellhead prices are assumed not to change substantially from today's levels in real terms,
- new technologies that are not readily foreseeable extensions of existing technology are not considered, and
- *demand* is assumed to be high enough to avoid reductions in production potential due to curtailment of investments in exploration and production.

The memorandum also summarizes the prospects for additional conventional supplies to the Lower 48 from pipeline imports from Canada, Alaska, and Mexico, liquefied natural gas (LNG) imports, and synthetic gas from coal. The final report of OTA's assessment also will evaluate the so-called "unconventional" sources of natural gas—gas in tight sands, Devonian shales, coal seams, and geopressurized brines.

MAJOR FINDINGS

Certain technical uncertainties—primarily those associated with incomplete geological understanding, alternative interpretations of past discovery trends, and difficulties in projecting likely patterns of future gas discoveries—are so substantial that by themselves they prevent a reliable estimation of the remaining recoverable gas resource and the likely year *2000* production rate. Even after ignoring the potential for significant changes in gas prices and technology in the future, OTA could not narrow its range of estimates of resources and future production beyond a factor of 2 from the lowest to the highest estimate. Inclusion of uncertainties associated with changing gas prices and market demand and the continuing evolution of gas exploration and production technology would undoubtedly widen the range still further.

Specific findings of the study are as follows:

- Current proved reserves in the Lower 48 States will supply only a few trillion cubic feet (TCF) per year of production by the year 2000. All other domestic production must come from gas which has not *yet been identified* by drilling.
- Ž There is no convincing basis for the common argument that the area of the Lower 48 States is so intensively explored and its geology is

so well known that there is a substantial consensus on the magnitude of the gas resource base. Plausible estimates of the amount of remaining conventional natural gas in the Lower 48 States that is recoverable under present and easily foreseeable technological and economic conditions range from 400 to 900 TCF. At the lower end of this range, production in the year 2000 will be seriously constrained by the magnitude of the resource base.

- Assuming market conditions favorable to gas exploration and production and no radical changes in technology or gas prices, plausible estimates of the year 2000 production potential of conventional natural gas in the Lower 48 States range from 9 to 19 TCF/yr. In 1990 production is likely to be anywhere from 13 to 20 TCF/yr.
- Because it is unclear whether the recent surge in the rate of additions to proved gas reserves' is sustainable, the range of plausible annual reserve additions is wide even for the near future. The range for the Lower 48 States for 1986 and beyond is from 7 or 8 TCF/yr up to 16 or 17 TCF/yr, assuming that the current excess of gas production capacity ceases and market conditions improve.
- The rate at which gas can be withdrawn from proved reserves, or R/P (reserves-to-production) ratio, may range from 7.0 to 9.5 as a national average by the year 2000, further adding to the difficulty of projecting future production potential.
- An important source of uncertainty in evaluating past discovery trends is the lack of publicly available, unambiguous, disaggregate data about gas discoveries.

● The 1981 addition was about 21 TCF versus about 10 TCF/yr or less for 1969-77.

NATURAL GAS PRODUCTION POTENTIAL

OTA finds insufficient evidence on which to base either an optimistic or a pessimistic outlook for conventional domestic gas production. Given market conditions favorable to gas exploration and production, the production of natural gas from conventional sources within the Lower 48 States could range from *9* to *19* TCF/yr by the year *2000*. Similarly, production in the year *1990* could range from 13 to *20* TCF/yr. * These ranges do not include gas from pipeline or LNG imports, synthetic gas from coal or other materials, or gas from unconventional sources that are not producing today. They do include gas from low-permeability reservoirs that is currently economically recoverable, even though this gas is borderline conventional and might be considered unconventional by some assessors.

OTA's wide range for plausible levels of conventional gas production in the Lower 48 States in the year 2000 is in sharp contrast to the relatively *narrow* range displayed in publicly available forecasts. Table 1 presents the summarized results of 20 separate forecasts from oil companies, other private institutions and individuals, and Government agencies. A striking feature of this group of forecasts is that 13 of the 14 forecasts that project a year 2000 production level fall within 11 to 15 *TCF/yr*. This high level of agreement for a production rate two decades in the future is made all the more unusual by the probability that there are substantive differences in the baseline assumptions used by the various forecasters. The high level of agreement might, however, reflect the probability that the forecasts are not all independent, original estimates; some may simply be averages of other forecasts, reflecting the "conventional wisdom, " and some may have been influenced by others that preceded them.

The wide range in OTA's projection of future gas production reflects the existing high degree of uncertainty about:

1. the magnitude and character of the gas resource base;
2. the appropriate interpretation and extrapolation of past trends in natural gas discovery, and;
3. the rapidity with which gas in proved reserves can be produced, expressed as the reserves-to-production (R/P) ratio.

*Current annual production is about 18 TCF/yr, and actual production *capacity* is probably 1 or 2 TCF/yr higher.

Table 1 .—Gas Production Forecasts (in trillion cubic feet)

	Oil companies	Other private	Government agencies	Average	OTA
1985					
Lowest	17.0	15.5	16.5	—	—
Average	18.7	17.1	17.3	17.9	—
Highest	19.5	18.3	18.0	—	—
1990					
Lowest	13.9	13.6	14.3	—	13
Average	17.1	15.4	15.1	16.7	—
Highest	18.8	17,7	15.5	—	20
2000					
Lowest	8.9	11.6	12,8	—	9
Average	13.5	12.2	13.1	13,1	—
Highest	14.6	13,5	13.5	—	19
Number of individual forecasts	9	6	5	—	—

NOTE All forecasts calculate gas on "dry" basis at standard temperature and pressure Some forecasts include unconventional sources of supply, such as tight sands and Devonlan shales; others Include only conventional sources

SOURCE Office of Technology Assessment, based on data in Jensen Associates, Inc "Understanding Natural Gas Supply in the U.S " contractor report to the Office of Technology Assessment, April 1983

The first two sources of uncertainty are inseparable; the magnitude and character of the resource base have played—and will continue to play—an important role in shaping trends in gas discovery, and these trends in turn provide important clues to gauging the remaining resource base. Consequently, uncertainties in trend interpretation automatically contribute to uncertainties in resource assessment, and resource uncertainties in turn complicate the processor projecting future discovery trends. Similarly, estimating future R/P ratios will depend on projecting discovery trends and understanding the character of the remaining resources.

Each of the three sources of uncertainty will be discussed in turn.

Uncertainty 1: The Gas Resource Base

Many individuals and organizations have published assessments of the natural gas resources of the Lower *48* States. Table 2 presents seven such estimates of the gas resources that remained in the Lower 48 at the beginning of 1983. They range from Hubbert's **244** TCF to the PGC's 916 TCF.

The resource estimates at high and low ends of the range in table 2 have quite different messages for gas production forecasters. At the upper end, the USGS and PGC estimates imply that gas production in this century will be relatively unconstrained because of the resource base magnitude—although this does not rule out the possibility that production may be sharply constrained by the *character* of the remaining resources. * In contrast, estimates at the lower end—Shell, Hubbert, RAND, and Bromberg/Hartigan—imply a serious resource constraint. If these estimates are correct, gas production will decline substantially by the year 2000 (see fig. 1). Therefore, selection of a "best" resource estimate, or narrowing of the range, could conceivably have profound implications for expectations of future gas production.

Table 2.—Alternative Estimates of Remaining Conventional Natural Gas Resources[a] in the U.S. Lower 48 States (as of Jan. 1, 1983)

Source[b] (publication date)	Trillion cubic feet
Hubbert (1980)	244
RAND Corp. (1981)	283
Shell (1977)	320
Bromberg/Hartigan (1975)	340
Wiorkowsky (1975)	663
U.S. Geological Survey (1981)	774
Potential Gas Committee (1983)	916

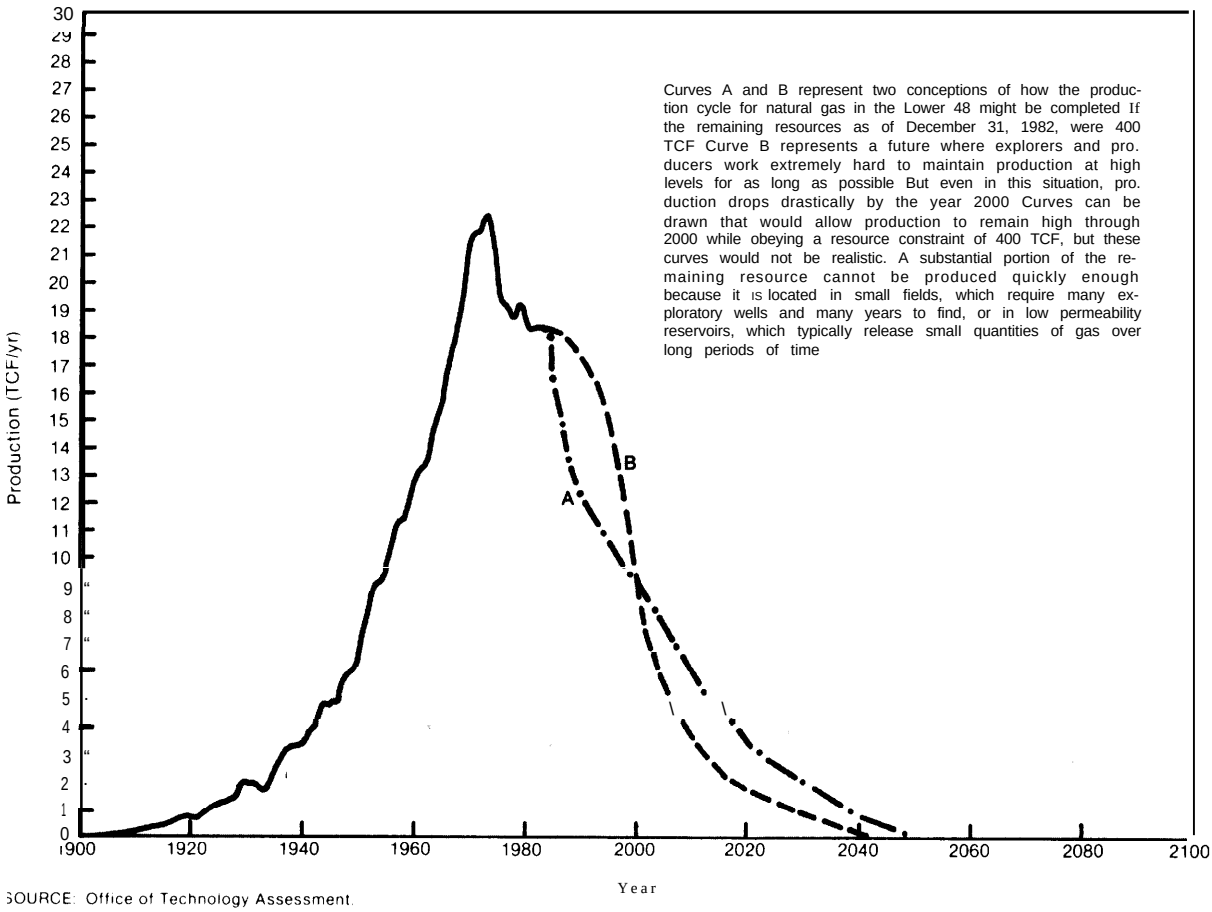
[a] The term "resources" includes proved reserves, expected growth of existing fields, and undiscovered recoverable resources In all but the Hubbert estimate, the term does not include gas not recoverable by current or readily foreseeable technology nor gas not recoverable at price/cost ratios similar to today's

[b] In most cases, the sources for these estimates were assessments of either the ultimately recoverable resource or the undiscovered resource base The est I mates shown are derived by subtract! ng cumulative product ION from estimates of ultimately recoverable e resource or by adding proved reserves and expected growth of known fields to estimates of the undiscovered resource Where ranges of resource estimates are given by the source, the estimate in this table is based on the mean value

SOURCE Office of Technology Assessment, 1983

*For example, by their location, depth, degree of contamination, and size distribution of fields and reservoirs.

Figure 1.—Alternative Concepts of the Natural Gas Production Cycle If Remaining Resources = 400 **TCF** (conventional gas only)



SOURCE: Office of Technology Assessment.

Some of the differences in the estimates may merely be the result of differences in baseline assumptions or boundaries. For example, various assessments may use different assumptions about economic conditions and the state of exploration and recovery technology and may have different geographical boundary conditions. They may or may not include areas currently inaccessible to development, gas from portions of tight sands or other "unconventional" sources that are presently recoverable, or nonmethane components of the gas. Finally, assessments may differ in their definitions of the degree of certainty that should be attached to the estimate. Unfortunately, many assessments do not fully specify their assumptions and definitions, nor is it always clear what effects these assumptions have on the resource estimates. Consequently, it is not possible to "normalize" the various estimates so that they are fully comparable. *

It is OTA's opinion, however, that "normalization" of the various estimates would not eliminate the major differences between them. OTA finds no convincing basis for the common argument that the area of the Lower 48 **States** is so intensively explored and its geology is so well known

● This does not imply, of course, that *some* normalization cannot be accomplished. For example, PGC has incorporated into its resource estimate quantities of presently recoverable gas in tight reservoirs, whereas both RAND and USGS have tended to exclude this gas from their resource estimates. Consequently, equalizing the conventional/unconventional boundaries of the assessments should reduce the differences between PGC's estimate and those of USGS and RAND.

that there is a substantial consensus on the magnitude of the gas resource base.

Instead, there are several substantive resource base issues that remain unresolved. Among the more important of these are:

The Use of Past Discovery Trends

The extrapolation of past trends in the discovery of natural gas has generally led to pessimistic estimates of the magnitude of the gas resource base. For example, of the resource base assessments examined by OTA, three of the four that used trend extrapolation techniques arrived at estimates that were at least 400 TCF below the USGS median estimate. Acceptance of discovery trend extrapolation as a valid method of resource base assessment, therefore, can yield conclusions about the magnitude of the resource base that are radically different from those that result from using other assessment methods.

The validity of using past discovery trends to estimate the magnitude of the resource base depends on whether the trends are affected more by the nature of the resource base than by the general economic and regulatory climate of the times. Resource "optimists" argue that the disappointing trends in gas discovery of the past few decades have resulted from controlled gas prices, high levels of proved reserves, and limited markets that until recently gave little incentive for high-risk or high-cost drilling, They argue that extrapolation of these trends is invalid because the economic and regulatory conditions that created the trends have changed. Resource "pessimists" argue that the trends are driven mainly by a depleting resource base and are affected only minimally by economic and regulatory conditions; therefore, extrapolation is valid.

In addition to this basic issue, other questions have arisen over the validity and interpretation of resource estimates based on extrapolation of past trends. For example, the accuracy of early records of gas discovery and production is questionable; thus, trend analyses cannot accurately incorporate the entire discovery and production history. Also, the precise economic, technological, geographic, and geologic boundaries of these estimates are difficult to define.

The Potential of Small Fields

Although fields that contain less than 60 billion cubic feet (BCF) of gas have played a minor role in gas production, some analysts believe that small fields will have a major role in the future. The *difference* between optimistic and pessimistic estimates of the future role of small fields may be 100 TCF or more. In OTA's judgment, the arguments on both sides are based primarily on unproven statistical models of field size distributions and on economic tradeoffs that are highly sensitive to gas prices. Only time and further exploration will settle this issue.

New Gas From Old Fields

There are sharp disagreements about the extent to which the resources recoverable from older producing fields may respond to price increases. The mechanisms to increase the "ultimately recoverable resources" of these fields might include lowering abandonment pressures, drilling at smaller spacing to locate gas pockets that otherwise would not be drained, and fracturing the reservoir rock to allow recovery from low-permeability portions of fields. Currently, estimates of the potential increase in recoverable resources range from a few TCF to about 50 TCF.

The Potential of Frontier Areas, Including Deep Gas

Although all resource analysts consider areas such as the deep-water Gulf of Mexico, the deep Anadarko Basin, and the Western Overthrust Belt to have considerable gas potential, considerable disagreement exists over the actual amount of recoverable resources in these areas. Recent indications of engineering problems and rapid pressure declines from deep wells in the Anadarko, coupled with price declines from previous very high levels, raise doubts about whether much of this area's gas resource will be part of the (currently) economically recoverable resource. In the Overthrust Belt, doubts about the magnitude of the resource center on the significance of the failure of explorers to find a giant field over the past 3 to 4 years. Also, areas such as the eastern Gulf of Mexico, the Southeast Georgia Embayment, the Georges Bank, and the Baltimore Canyon have been ex-

pensive failures thus far, and their eventual contribution to satisfying U.S. energy requirements is unknown,

Estimates of the recoverable resource potential in the frontier areas vary by up to 100 TCF or more (the USGS and PGC differ by nearly 30 TCF in their assessments of the eastern Gulf of Mexico, alone).

The Potential of Stratigraphic Traps

Stratigraphic traps are barriers to petroleum migration formed by gradual changes in the permeability y of sedimentary layers rather than by abrupt structural shifts and deformation of the layers. Because the structural traps are easier to locate, they have been the primary targets for exploration. Some explorers predict that large resources remain to be found in "mature" areas in subtle stratigraphic traps. Although this issue is not settled, the optimistic argument is weakened by observations that numerous stratigraphic traps *have* been found in the Permian Basin and elsewhere and that the extensive drilling in areas that appear to have good prospects for stratigraphic traps should have uncovered most of the larger traps, which generally are extensive in area. Though it may appear more likely than not that most of the remaining undiscovered traps will be small in volume, a possibility exists that larger fields may have remained hidden because of the less effective exploration methods used in the past and drilling that, while extensive, might have clustered in the wrong places or been too shallow.

In addition to these five issues, a level of uncertainty is ever present in the process of estimating the quantity of a resource that cannot be measured directly prior to its actual production. The presence of economically recoverable concentrations of natural gas requires an unbroken chain of events or conditions, the presence or absence of which generally cannot be measured directly. First, adequate amounts of organic material and suitable temperature and pressure conditions for gas formation and preservation must be present. Second, the gas must be free to migrate, and third, an adequate reservoir must be available in the path of migration to contain the gas. Finally, there must be a mechanism to trap the gas, and the trap must remain unbleached until the gas is discovered and produced. These sources of uncertainty account for the various manifestations of risk in natural gas development—the large number of dry holes drilled during exploration, the often huge differences in bids for leases, the multimillion dollar failures of many of the leased areas, and the continuing disagreements over the size of the remaining resource.

OTA took into account these general issues, as well as specific problems with individual assessments, in arriving at a plausible range for the amount of remaining gas resources. In OTA's judgment, a reasonable range for the amount of the remaining conventional natural gas in the U.S. Lower 48 that is recoverable under present and easily foreseeable technological and economic conditions is 400 to 900 TCF as of December 1982. This range is somewhat narrower than the range displayed in table *2*, because OTA considers the low end of the range of resource estimates in the table to be overly pessimistic. However, the general implication of OTA's range is similar to the implication of the range in the table: The uncertainty in estimating the remaining recoverable gas resource is too high to determine whether or not the resource base magnitude will constrain gas production in this century. On the other hand, even the more optimistic resource estimates imply that conventional gas production must decline sharply by the year 2020 or before unless technological advances and/or sharp increases in gas prices add substantial quantities of gas to the "economically recoverable" category.

Uncertainty 2: Interpretation and Extrapolation of Discovery Trends

The key to projecting gas production potential to the year *2000* is the successful prediction of future discovery trends and of additions to proved reserves. This focus on the discovery process is necessary because gas that is already discovered, that is, gas in proved reserves, will be of diminishing importance to production as we move into the 1990's. Assuming a constant R/P ratio of *8.0,* the current proved reserves of about 169 TCF in the Lower 48 will provide only 2 TCF to total production by the year 2000. All other production

must come from gas added to proved reserves by the discovery of new fields, the discovery of additional reservoirs in known fields ("new pool discoveries"), the expansion of the areas of known reservoirs ("extensions"), and the reserve changes due to new information or changed economics or technology ("revisions'').*

In addition to the effects of resource base uncertainty, interpretation and extrapolation of discovery trends are hampered by a variety of other problems. These include:

Inadequate Discovery Indicators

The interpretation and extrapolation of trends for projecting future reserve additions require the availability of discovery "indicators," such as finding rates for new field wildcats, that can be interpreted in a relatively unambiguous fashion. OTA found that essentially all indicators available from public data that describe the natural gas discovery process have ambiguous interpretations because the data are highly aggregated and are dependent on a wide variety of factors. For example, the "exploration" whose success is being measured by a finding rate actually includes several kinds of exploratory drilling, from high-risk, high-return drilling that searches for giant fields in new geologic horizons, to low-risk, low-return drilling that clusters around a new strike or redrills already explored areas that have grown more attractive with price increases. Because the proportions of different varieties of exploratory drilling may change substantially with changing market conditions, interpreting trends in finding rates and other indicators of exploration success is difficult. This is especially true if the data are highly aggregated geographically.

Uncertainty About the Future Growth of New Fields

At least three-quarters of past additions to proved gas reserves have come from the discovery process that *follows* the discovery of new fields. This secondary discovery process seeks new reservoirs in the field and the expansion of known boundaries of already discovered reservoirs. The extent to which recently found fields and future fields will grow in the same manner as fields found in the past is critical to future reserve levels and thus to future production. There has been speculation that the decline in finding giant fields—which require many years and discovery wells to develop fully—and the addition to the reserve base of increasing numbers of very small fields will lead to significant declines in field growth. If the new fields discovered in the past few years do not grow at near-historic levels, then reserve additions due to new pool discoveries and extensions will decline substantially from recent levels, even if new field discoveries can stay at their present higher rate. OTA believes that such a decline in field growth is plausible, but verification requires additional analysis at the individual field level and continued observation of field growth trends.

Difficulties in Interpreting the Recent Surge in Reserve Additions

After the decade 1969-78, during which additions to gas reserves in the Lower 48 States averaged less than 10 TCF/yr,* reserve additions have surged to over 20 TCF* * in 1981 and are expected to be nearly as high in 1982. This surge has been the centerpiece of arguments for future high production levels,

In OTA's judgment, it is not clear whether or not the recent high rates of additions to proved gas reserves are sustainable, even if drilling rates rebound to the levels achieved before the recent slump. For example, 13.5 TCF of the total 1981 additions came from secondary discoveries, that is, extensions and new pool discoveries. Normally, such a surge in secondary discoveries would be preceded a few years earlier by an increase in new field discoveries, because recently discovered fields provide the most promising target areas for secondary discoveries. However, the number of new fields discovered in the 5 years before 1981 did not seem high enough to be the primary cause of 1981's high secondary discoveries. Alternative or additional causes of the recent increases in sec-

*This last category of reserve additions may be negative.

*As reported by the American Gas Association.

* *As reported by the Energy Information Administration The American Gas Association, the major source of reserve data prior to 1977, no longer publishes detailed information on reserve additions.

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ondary discoveries could include: an acceleration in the normal pace of field growth (e. g., growth that normally might occur over a 20-year period instead is achieved in 5 years, yielding a short-term increase in "per year" reserve additions followed by a dropoff in later years); the rapid development of a limited inventory of low-risk drilling prospects that had been identified in prior years but ignored because of unfavorable economic conditions; and a substantially increased growth potential for the current (and future) inventory of discovered fields because of the expansion of recoverable resources with higher prices and improved exploration and production technology. The first two causes would imply that secondary discoveries will decline sharply in the near future as the limited inventory of prospects is used up; the third cause implies that high levels of secondary discoveries might be sustainable. In fact, it is likely that all three causes played a role in the recent surge, but their relative share is uncertain.

Similarly, it is not clear to what extent recent higher reported rates of new field discoveries are caused by any (or all) of the following factors: an increased willingness of explorers to go after riskier prospects; the exploitation of a limited inventory of low-risk prospects identified by past exploration; an increase in the number of economically viable fields, caused by improved technology and higher prices; and recent changes in reserve reporting methodologies. *

OTA projected a plausible range of future additions to Lower *48* gas reserves by trying to account for uncertainties about the resource base magnitude, the resource characteristics most likely to affect the discovery process, and the actual causes of past and recent discovery trends. OTA concluded that, under the assumed demand/price/technology conditions, multiyear average levels of total reserve additions could range from 7 to 8 TCF/yr to 16 to 17 TCF/yr or higher by 1986. Projected average values for individual components of reserve additions are:

New field discoveries . .	1.5-3.5 TCF/yr
Extensions and new pool discoveries	6.0-11.0 TCF/yr
Revisions	O-+ 2.0 TCF/yr

Uncertainty 3: Production From Proved Reserves-The RIP Ratio

The reserves-to-production (R/P) ratio reflects the rate at which gas is being withdrawn from discovered reservoirs; consequently, it represents the analytical link between projections of new discoveries and forecasts of gas production. There are very large differences in R/P ratios from field to field, depending on the age, geology, location, and contract terms of the gas production. OTA projects that the aggregate average R/P ratio for the Lower 48 may range from 7.0 to 9.5 by the year 2000, assuming that economic conditions are generally favorable to production (in other words, in contrast to today's gas "bubble"). The R/P ratio in 1981 was 9.0, the result of a long and relatively steady decline from a level of *30* in 1946.

Although the R/P ratio is sensitive to economic factors, such as actual and expected gas prices and interest rates, technical factors will also play an important role in determining this ratio in the future. Gas in low-permeability reservoirs will play an increasing role in reserves, tending to push up R/P levels. The importance of offshore development will affect national R/P levels because offshore fields have typically been exploited very quickly. As more and more gas is produced in frontier areas with very high drilling costs, difficult tradeoffs will have to be made between the desire for rapid production and the costs of drilling additional development wells. The rate of adding new reserves—which itself is highly uncertain—will determine the average age of the United States' producing fields, an important factor in production rates. Uncertainty in these factors makes it difficult to predict whether future average R/P levels will increase or decrease from today's level.

*The American Gas Association reported U.S. reserve additions until 1979, The Energy Information Administration began reporting reserve additions in 1977 using a different data collection and analysis procedure, and modified this procedure in 1979.

Summary of Assumptions and Conditions Underlying OTA's Projections

Table 3 summarizes the assumptions and conditions that lead to the low and high ends of OTA's projection for conventional gas production for the Lower 48 States in the year 2000.

Table 3.– Bases for OTA's Projections of Natural Gas Production— Baseline Assumptions: Good Market Conditions, Readily Foreseeable Technology

9 TCF/yr in 2000	19 TCF/yr in 2000
1. ***Magnitude of remaining resources:*** ***400*** TCF	900 TCF
2. Character of remaining resources: Remaining exploration plays[a] are only of moderate size; few surprises. Some major potential remaining in frontier areas but deep resource is disappointing. Small fields are only a minor source of additional gas because of economics and/or smaller numbers than a straight-line extrapolation would predict. Resource in strati graphic traps is disappointing; remaining growth of old fields is moderate.	High potential for major new exploration plays. Deep resource is both plentiful and economically accessible. Small fields may play an important role, but many large fields still remain. Resource remaining in mature areas, much of it in subtle strati graphic traps, is substantial. Remaining growth of old fields is high.
3. ***Causes of past trends in gas discovery:*** Magnitude and character of the resource base were the primary causes.	Artificially low prices and rigid regulation were as important as the resource base.
4. Meaning of recent surge in reserve additions: A temporary response to higher prices, drilling a backlog of easy but formerly marginal prospects—not sustainable. Possibly also caused by a change in reporting practices,	An indication of a real turnabout in gas discovery; the opening up of major new exploration horizons, readily sustainable if exploratory drilling revives.
5. Projected rate of future annual reserve additions: Total: Declines to 7,5 TCF by 1986: New field discoveries: 1.5 TCF Extensions and new pool discoveries: 6.0 TCF by 1986 Revisions: O	Maintained at 16.5 TCF or above for the next few decades: 3.5 TCF 11.0 TCF + 2.0 TCF
6. R/P ***Ratios:*** ***9.5*** by ***2000,*** predicated on lower permeability reserve additions, difficult production conditions.	7.0 by 2000, predicated on high demand coupled with generally favorable physical conditions,

[a]Play — An exploratory campaign based on a cohesive geologic idea

SOURCE Office of Technology Assessment, 1983

OTHER SOURCES OF LOWER 48 SUPPLY

Aside from domestic conventional gas production, gas consumers in the Lower 48 States may have access to other sources of supply, including production from so-called unconventional sources (tight sands, coal beds, gas in geopressurized aquifers, and Devonian shales); pipeline imports from Alaska, Canada, and Mexico; LNG imports from a variety of gas-producing nations throughout the world; and synthetic natural gas from coal and biomass. The potential supply from unconventional sources will be discussed in a future report of OTA's U.S. Natural Gas Availability

study. OTA previously discussed synthetic natural gas in a report released in 1982.[1]

The United States currently imports about 0,9 TCF of gas per year, most of it from Canada. Because each of the four sources of gas import potential have substantial and accessible resources, imports could theoretically satisfy a major portion of U.S. gas requirements later in this century and beyond. However, each of the import sources, like future domestic production, is subject to considerable uncertainty. High transportation costs are a particular problem for Alaskan gas and LNG, creating the need, at a minimum, to accept wellhead prices substantially below equivalent oil prices. Similar problems exist for Canadian and Mexican gas. Canadian and Mexican exports to the United States must also compete with the uncertain future requirements of their own domestic gas users. Based on available studies, the expected import potential from Canada, Alaska, and Mexico may range from 1.0 to 7.4 TCF in the year 2000, with Canada being the most certain large contributor. LNG imports are even less predictable. Finally, OTA projects synthetic natural gas from coal to range from O to 1.6 TCF/yr by the year 2000.

[1] *Increased Automobile Fuel Efficiency and Synthetic Fuels: Alternatives for Reducing Oil Imports* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-E-185, September 1982)