

**PROVED DISCOVERIES  
AND  
PRODUCTIVE CAPACITY**

**OF  
CRUDE OIL, NATURAL GAS,  
AND NATURAL GAS LIQUIDS  
IN THE  
UNITED STATES**

**A REPORT OF  
THE NATIONAL PETROLEUM COUNCIL**

**1961**

REPORT OF THE  
NATIONAL PETROLEUM COUNCIL COMMITTEE  
ON PROVED PETROLEUM AND NATURAL GAS RESERVES AND AVAILABILITY

MAY 15, 1961

CHAIRMAN OF THE COMMITTEE: L. F. McCOLLUM

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(1960)

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# NATIONAL PETROLEUM COUNCIL

*(Established by the Secretary of the Interior)*

1625 K STREET, N. W.

WASHINGTON 6, D. C.

Walter S. Hallanan  
*Chairman*

R. G. Follis  
*Vice-Chairman*

James V. Brown  
*Secretary-Treasurer*

May 15, 1961

Mr. Walter S. Hallanan, Chairman  
National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

Dear Mr. Hallanan:

On September 30, 1959, Mr. Elmer F. Bennett, Acting Secretary of the Interior, sent a letter to the Chairman of the National Petroleum Council requesting a study of proved reserves and productive capacity of crude oil. Subsequent letters clarified and expanded that request. In accordance with recommendations of the Agenda Committee, at meetings on October 19, 1959, and March 21, 1960, a Committee on Proved Petroleum and Natural Gas Reserves and Availability was appointed and was asked to develop the following information:

- (1) The proved reserves of crude oil by PAD districts arranged according to the year of discovery of each field. Information available as of December 31, 1959, was to be employed in the analysis, but the tabulation by field discovery dates was to terminate with the year 1954.
- (2) The proved reserves of natural gas and natural gas liquids compiled on a comparable basis to the proved crude oil reserves.
- (3) The drilled and undrilled proved acreage on December 31, 1959, if feasible.
- (4) The productive capacities of crude oil, natural gas, and natural gas liquids as of January 1, 1960, with projections for January 1, 1961, and January 1, 1962.

The individual letters requesting the above information are reproduced in Exhibits A through F.

The Committee was authorized to include in its report appropriate comments, clarifications, and explanation necessary for the proper understanding and evaluation of the data.

To develop the information that had been requested, the Committee on Proved Petroleum and Natural Gas Reserves and Availability established two coordinating subcommittees. One was responsible for the crude oil portion of the study. The other was responsible for the natural gas and natural gas liquids portion. Many additional working groups were appointed. These groups were comprised, for the most part, of engineers and geologists who have had many years of experience with the problems involved in studies of this nature. In all, over 100 men served directly in the preparation of this report. Also, information was obtained locally through the generous cooperation of many producers, pipeline companies, and gasoline plant operators, both large and small.

Because of the exceedingly large number of individual fields and reservoirs in the United States and the large variations in well spacing, it was not found feasible to develop data on the drilled and undrilled proved acreage.

The results of the Committee's studies are presented in this report in several sections that deal separately with discoveries of crude oil, natural gas, and natural gas liquids, and with the productive capacities of these materials. The report also contains a number of comments and explanations with respect to proper interpretation of the data and the limitations of certain possible interpretations. The most important of these comments are found in the summary section which follows this letter.

Respectfully submitted,

/s/ L. F. McCollum

L. F. McCollum, Chairman  
NPC Committee on Proved Petroleum  
and Natural Gas Reserves and  
Availability (1960)

## SUMMARY

This report combines in a series of separate sections the results of studies made during the year 1960 by the Coordinating Subcommittee for Proved Crude Oil Reserves and Availability and the Coordinating Subcommittee for Natural Gas and Natural Gas Liquids Reserves and Availability in response to a series of requests by the U. S. Department of Interior to the National Petroleum Council. Two main subjects are dealt with: first, historical tabulations of discoveries of crude oil, natural gas, and natural gas liquids in the United States and, second, estimates of the productive capacities of these materials as of January 1, 1960, with projections of productive capacities for January 1, 1961, and January 1, 1962.

### Discoveries

The historical tabulations of proved discoveries of crude oil, natural gas, and natural gas liquids are summarized for the United States and by PAW districts in Tables I, II, and III. These tabulations do not represent new and original findings by this Committee with respect to reserves in the United States, but in essence are a recasting of already known reserves estimates as of December 31, 1959. United States reserves have been reported

annually for some time by the American Petroleum Institute and the American Gas Association. Contrary, however, to the usual API and AGA practice, the estimates presented in this report have been arranged at the request of the Department of the Interior according to the discovery years of the fields\* to which the reserves are attributed and the tabulations are carried only through the year 1954.

The discovery estimates given in this report represent the total expected recoveries, including both past production and remaining proved reserves, based upon field size and past performance as such factors were known on December 31, 1959.

The usual practice of the industry in the determination of reserves is quite different; the interest normally lies in the remaining reserves.

In subsequent sections of this report, it is shown by comparisons of the present estimates of discoveries with prior

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\* Because of the exceedingly large number of individual reservoirs now recognized in many fields, the decision as to whether a new reservoir in an old field should be considered an extension of the old field and be given the discovery year of the old field, or whether, conversely, the new reservoir should be considered a later discovery was left to the discretion of the individual local subcommittees and working groups. In this report, therefore, some new reservoirs have been treated as if discovered in earlier years and others have been given later discovery dates. A check of the results assures this Committee that the treatment in individual cases has resulted in a sound answer.

estimates made by others that the estimated recovery from the average field usually increases several fold over the estimate made at the end of the discovery year and continues to increase from various causes for a great many years. The tabulations presented are useful, therefore, in providing through such comparisons insight into the magnitude and rate of increase of recovery estimates. In spite of the paucity of earlier estimates of discoveries, the available data are adequate to show in the case of oil that the fields already discovered in the United States represent an enormous base for possible future additions to reserves through further extensions and revisions. It is evident, therefore, that studies of the long term future supply of oil in the United States must give cognizance not only to the possible future discoveries of new fields but also to the future additions to reserves from existing fields.

Because of the growth in estimated recovery as more is known about a field and technology improves, a proper analysis of discovery trends would require comparison of annual discoveries estimated by comparable methods at equal time intervals after discovery. It is important to recognize that the historical discovery tabulations presented in this report are not so constructed but represent, instead, a single set of estimates, all based on data available at the end of 1959. The fields discovered

in 1954 have been credited with only five years' revisions, whereas those discovered in earlier years have been credited with revisions for progressively longer intervals ranging back to over 40 years for fields discovered prior to 1919. The resultant distortion is far too great to permit sound deductions with respect to discovery trends from these tabulations alone. The Committee wishes to emphasize, therefore, that the historical tabulations presented in Tables I, II, and III of this report do not provide a valid measure of either the amount discovered in prior years or of discovery trends.

#### Productive Capacity

The productive capacities of crude oil, natural gas liquids, and natural gas on January 1, 1960, were estimated to be:

Crude Oil:	10,585,000 barrels daily
Natural Gas Liquids:	1,799,600 barrels daily
Natural Gas:	71,504,000 thousand cubic feet daily

Details with respect to the estimates of productive capacity are reported in Tables IV-VII. The estimated productive capacity of crude oil is comparable with prior studies prepared for the National Petroleum Council. Estimates of productive capacity of natural gas have not been prepared heretofore. An explanation of this estimate is given in a later section of this report. The preceding estimate of the productive capacity of natural gas liquids is not comparable with estimates heretofore

prepared for the National Petroleum Council. It represents the natural gas liquids that would have been potentially recoverable if the production of crude oil and of natural gas on January 1, 1960, had been at the capacity rates shown.

The estimates given in the report for productive capacities represent the rates at which oil, gas, and natural gas liquids could be produced from existing fields and wells without regard to such limitations as lack of surface facilities for handling, processing, storage, or transportation. Also, governmental regulations under normal peacetime conditions, whether by agencies of the Federal Government or individual states, are another limitation. The productive capacity is therefore a measure of potential rather than actual availability. The difference between productive capacity as used in this report and actual availability may be quite large for crude oil, and even greater in the case of natural gas and natural gas liquids.

Because of the many qualifications and limitations pointed out in this report with respect to all of the attached tables, the Committee wishes to emphasize that a complete reading of the text is required for their proper understanding and use. It is requested, therefore, that these tables not be separated from or used independently of the text.

## HISTORICAL DISCOVERY TABULATIONS

### Basis of the Tabulations

The historical tabulations of discoveries presented in this report do not represent new and original findings by this Committee with respect to reserves in the United States but reflect, in essence, a recasting on a discovery-year basis of the already known reserves of oil and gas in the United States at the end of 1959. These tabulations were prepared in accordance with a specific request by the Department of the Interior that the crude oil reserves as estimated by the API at the end of 1959 be credited back to the year of discovery of each field and be arranged in tabular form to provide a historical record of discoveries in essentially the same fashion as had previously been done by the Petroleum Administration for War in 1945. (See Exhibit A) The PAW report was considered by the Interior Department to have been "very valuable in appraising the trend of results obtained from exploration," and the National Petroleum Council was requested to revise and update the PAW report through 1954 to meet a need in connection with the Government's efforts to appraise the long term supply and demand position of the United States.

Since the published reports of the API Reserves Committee are not in such form as to provide the detail required for

compliance with the Government's request, the NPC Committee assembled the necessary data on individual fields. (See Exhibit B) These data were then used as the basis for the requested tabulation arranged according to the discovery years of the individual fields.

Subsequent to the original request with respect to crude oil, the Council was requested to prepare similar historical tabulations dealing with reserves of natural gas and natural gas liquids. Pursuant to these requests, the Committee on Proved Petroleum and Natural Gas Reserves and Availability was appointed, together with a Coordinating Subcommittee for Proved Crude Oil Reserves and Availability and a separate Coordinating Subcommittee for Natural Gas and Natural Gas Liquids Reserves and Availability. Additional subcommittees and working groups were appointed to enable each of the Coordinating Subcommittees to carry out its assignments. The reports of the two Coordinating Subcommittees are combined herein.

#### Basis of Usual Reserves Reports - Proved Reserves

Because the original request from the Department of the Interior had been on the basis of a retabulation of crude oil reserves as estimated by the API, and since the reserves estimates for crude oil, natural gas, and natural gas liquids prepared annually by the Reserves Committees of the American Petroleum

Institute and the American Gas Association have long been recognized as authoritative, the NPC subcommittees endeavored insofar as possible to employ the same methods and concepts in estimating discoveries as are used by the API and AGA reserves committees. The results reported herein are therefore believed not to differ significantly with respect to the total amounts of oil, gas, and natural gas liquids discovered in the United States.

In particular, the subcommittees have adhered to the concept of "proved" reserves, which, according to the API Committee, "refer solely to blocked-out reserves. They include only oil recoverable under existing economic and operating conditions" and, according to the AGA Committee, "proved reserves of natural gas are those reserves estimated to be producible under present operating practices . . ." This concept of proved reserves is very useful. It involves no speculation with respect to future discoveries or future technology. It is not intended to measure either the ultimate oil and gas resources of the United States or even the total possible future recovery from presently known fields. It provides, instead, a definite measure of the amount of oil or gas demonstrated by past development and considered beyond reasonable doubt to be recoverable from presently known fields by methods in actual operation and under conditions currently prevailing.

## Conversion from Remaining Reserves to Total Discoveries

In adherence to the aforementioned API-AGA concept of proved reserves, the Committee has included in its estimates only those quantities of oil, gas, and natural gas liquids known as of December 31, 1959, to be recoverable from existing fields. However, since the present study is concerned with past discoveries rather than an inventory of remaining reserves, the estimates have been expressed in terms of the total quantities now estimated to be recoverable from existing fields, including both past production and remaining reserves.

## Growth in Recovery Estimates

When a new field is discovered it is customary to make a preliminary estimate of its expected recovery. At the end of the discovery year, the amount of oil or gas known to be recoverable may be only a small fraction of the amount that will ultimately be recovered. As drilling proceeds in subsequent years and as more information is gained, the estimates of recovery will usually increase until development is complete. Thereafter, the estimates may continue to change from time to time. Disappointing performance may cause a downward revision. More often, however, later appraisal will lead to upward revision. Further additions to the estimate may be made as a result of improved recovery measures, such as inauguration of pressure maintenance or secondary recovery

in an oil field. Still further increases may result at any time through enlargement of a field by exploratory drilling, which may merely extend the field beyond its previously known limits or may find new pools. Thus each new field becomes the origin of a continuing stream of additions to reserves.

Through the reports issued annually since 1936 by the API Reserves Committee and since 1945 by the AGA Reserves Committee, the industry has grown accustomed to recognition of the aforementioned additions to estimates of recoveries as an important factor in the continued growth of oil and gas reserves in the United States.

#### Limitations of Discovery-Year Tabulations

In spite of the similarity in fundamental concepts of evaluation employed in the present study and by the API and AGA Reserves Committees, the method of tabulating the results in this report differs drastically from that used by the API and the AGA. In compliance with the request of the U. S. Department of the Interior, the total quantity of oil, gas, or gas liquids now considered to be proved recoverable from each field is assigned in this report to that field as if that amount had been proved recoverable at the time the field was discovered. The discoveries so attributed to the individual fields are then arranged according

to the years in which the fields were discovered, instead of according to the API-AGA method by which additions to reserves are credited in the years in which the oil, gas, and gas liquids were proved to be recoverable. The method of tabulation employed in this report would indicate that the quantities shown were discovered in the years listed, which is not true.

#### Tabulations Do Not Show Discovery Trends

Since the petroleum industry is not accustomed to data arranged by discovery years as in this report, caution is required to avoid confusion or erroneous deductions. In particular, these data do not measure discovery trends. The quantities of hydrocarbons shown for the fields discovered in a listed year do not represent the amounts that were originally believed to have been discovered in that year; neither are they the amounts that might ultimately be recovered from the fields discovered in that year. The full extent of the amounts that will ultimately be recovered from the fields considered will not be known until many years in the future when each of the fields will have been fully explored and finally depleted. Correspondingly, the amounts now considered to be recoverable differ greatly from the amounts that would have been considered recoverable at the time of discovery. For example, and with respect particularly to the fields discovered in the earlier years, quantities are now credited as recoverable by

application of techniques that were not even known or in use at the time of discovery of the fields.

#### HISTORICAL DISCOVERY RECORD FOR CRUDE OIL

Since the NPC working committees employed essentially the same methods and concepts as the API committee uses in its annual estimates of proved reserves, helpful perspective on the discoveries of crude oil in this report may be gained by referring to the API estimates of proved reserves.

#### Reconciliation with API Reserves Estimate for 1959

The proved reserves of crude oil in the United States at the end of 1959 were estimated by the API to total 31.7 billion barrels. Cumulative production of crude oil as of the same date was approximately 62.6 billion barrels, indicating total discoveries of crude oil from 1859 through 1959 of 94.3 billion barrels as estimated by the API at the end of 1959. The historical tabulation presented in Table I of this report shows 91.4 billion barrels of the total oil discovered through 1959 to be assigned to fields discovered through 1954. The remaining 2.9 billion barrels represents the 1959 estimate of recoveries from fields discovered during 1955-59, together with the net total of any differences in estimated recoveries between the API committee and the NPC committee.

### Need for Comparison with Other Studies

For reasons summarized on the preceding page, the Committee has concluded that the record presented in Table I does not represent the trend of crude oil discoveries. It is important, therefore, to explore the manner in which this tabulation might be useful in fulfilling the stated need of the Department of the Interior in connection with its efforts to appraise the long term petroleum supply and demand position of the United States (Exhibit A). It appears to the Committee that this usefulness must lie primarily in the insight that might be provided, through comparison with other studies, into the magnitude and rate of increase of estimated recoveries from previously discovered fields. Unfortunately, such comparisons are limited by the paucity of reserves estimates in earlier years. However, from such data as are available, it becomes evident that a much larger quantity of additional oil may be expected in future years to be recoverable from existing fields than is reflected by the present estimates of proved discoveries. This additional oil will come from extensions of existing fields by future drilling, by upward revisions of recovery estimates as more knowledge of the reservoirs is obtained, and by increased recoveries through application of improved recovery techniques.

### Significance of Extensions and Revisions

The basis for the foregoing conclusion may be illustrated by reference to the annual reports of the API Reserves Committee and to the 1945 PAW study. Initial recoveries assigned by the API to new fields and new pools from 1936-1959 totaled 10.92 billion barrels. However, the total additions to reserves by the API over this period were approximately 63.1 billion barrels, or 5.8 times the amount assigned to new fields and new pools. Nearly 83 per cent of the total oil added to reserves came from extensions and revisions. The ratio of total oil added to reserves to the amount assigned to new fields and new pools has grown steadily from 1937 to 1959. This record indicates that the estimates of recoverable oil from new fields and new pools at the end of the discovery year represent only a small fraction of the oil that will ultimately prove to be recoverable from those fields.

### Comparison with PAW Report

It might be supposed that after a few years the estimated recovery from a field would reach a limit and thereafter cease to change. However, comparison of the tabulations in this report with the PAW study and with the API estimates shows that the upward growth of recovery estimates continues for a great many years. For example, it was estimated by PAW at the end of 1944 that the recoverable oil attributable to all fields discovered

from 1859 through 1919 totaled 14.64 billion barrels. The present estimate by this Committee, based on data available at the end of 1959, raises the total to 17.37 billion barrels, an increase of 18.6 per cent. All of these fields were 25 years old or older at the time of the PAW study in 1945; yet, during the ensuing 15 years from 1944-1959, an additional 2.73 billion barrels was added to the estimated recovery. For the more recent years, the upward revisions in recovery estimates during the 15 years between the PAW and NPC studies show much greater increases. A comparison of the present estimates of discoveries with the estimates reported by the PAW is summarized by 5-year periods in the following tabulation:

COMPARISON OF PRESENT ESTIMATES OF DISCOVERIES OF CRUDE OIL  
WITH PAW ESTIMATES FOR FIELDS DISCOVERED IN UNITED STATES  
THROUGH 1944

(Millions of Barrels)

<u>Fields Discovered During Period</u>	<u>PAW Estimate Made in 1945</u>	<u>NPC Estimate Made in 1960</u>	<u>Per Cent Change in Estimate, 1945-60</u>
Total through 1919	14,640	17,367	+ 19
1920-24	5,290	8,927	+ 69
1925-29	7,211	9,967	+ 38
1930-34	10,608	13,364	+ 26
1935-39	9,130	14,534	+ 59
1940-44	<u>5,243</u>	<u>9,452</u>	+ 80
Total 1920-44	37,482	56,244	+ 50

It will be noted that the disparity in the above comparison is substantial. Not only were the estimates for fields discovered

during the period 1940-44 increased, as was to be expected, but estimates for the fields discovered in earlier years were increased likewise. For example, for the fields discovered from 1920-24, which was 20 to 25 years before the PAW study, the present study attributes estimated discoveries greater by 69 per cent. The differences between the two estimates vary for the intervening five-year periods, ranging from 26 per cent for the fields discovered from 1930-34 to 59 per cent for those discovered from 1935-39. For the whole interval 1920-44, the present estimate of proved discoveries exceeds by 50 per cent the amount estimated by PAW to have been proved recoverable.

#### Comparison with API Estimates for New Fields and Pools

Further insight into the growth of recovery estimates may be obtained by comparison of the API estimates for new fields and new pools with both the PAW and NPC estimates for the same period. For the years 1937-1944, inclusive, the API showed a total of 3.85 billion barrels discovered in new fields and new pools. Estimated recoveries assigned by PAW at the end of 1944 to fields discovered in those years totaled 10.63 billion barrels, and the total assigned by NPC at the end of 1959 to fields discovered in those years totaled 17.57 billion barrels. The estimated recovery had grown 2.8 fold by the end of 1944 and 4.6 fold by the end of 1959.

## Importance of Future Increases in Recovery Estimates

The assignment to this Committee did not encompass a study of the long term future supply and demand of oil, gas, and natural gas liquids in the United States nor a projection of trends but was limited to findings of fact. The Committee was requested, however, to offer such appropriate comments, clarifications, and explanations as might be required for proper understanding and evaluation of the data.

The Committee offers, therefore, not by way of a projection but to illustrate the significance of the growth in recovery estimates, one additional comparison of the present recovery estimates with those estimated by the PAW. All of the recoverable oil in fields discovered from 1859 through 1939, a terminal date five years prior to the PAW study, was estimated by PAW to have totaled 46.9 billion barrels. The present estimate, 15 years later, shows 64.2 billion barrels now attributable to these same fields, an increase of over 17 billion barrels, or 37 per cent.

## Summary of Preceding Comparisons

The Committee is well aware, of course, that the increases in estimates of recoverable oil from fields previously discovered do not take place automatically with the passage of time, but, instead, are the direct result of further drilling,

the development of additional information, and the application of improved recovery procedures. The rates at which these activities take place may be accelerated or slowed down, depending upon the prevailing opportunities, economic incentives, and other influences, including governmental policies. The comparisons provided in this report might be more specifically interpreted, therefore, as follows:

1. The estimated proved recovery from newly discovered fields, when estimated at the end of the discovery year by the concepts and methods commonly employed in the petroleum industry, usually represents only a very small fraction of the oil that will ultimately prove to be recoverable.

2. The average newly discovered field becomes a new source of a continuing stream of additions to reserves, the growth in estimated recovery being reflected in extensions and upward revisions.

3. The growth in estimated recovery from the average field does not cease after a few years, but continues for a very long period. Comparisons between the estimates in the present report and other earlier studies show that growth is still taking place in estimated recoveries of fields over 40 years old.

4. The aggregate of all fields heretofore discovered, which is comprised of a distribution of fields in all states of development, from newly discovered ones to those a century old, represents an enormous base for future additions to reserves through further extensions and revisions.

5. The ultimate magnitude of future extensions and revisions of estimated recoveries from presently existing fields has not been determined. In principle, it must be limited to complete recovery of the oil in place. However, the available data do not indicate that this theoretical limit is, as yet, a restrictive influence on growth in recovery estimates.

6. It is evident from the foregoing considerations that studies of the long term future supply in the United States must give cognizance not only to the possible future discoveries of new fields but also to the future additions to reserves from existing fields.

7. The rate of discovery of new fields and the rate of increase in estimated additions to reserves of existing fields are not simple functions of time but are related to the intensity of the effort expended in the search for oil, in both exploratory and development drilling, and in technologic development and its application through improved recovery methods. The intensity of these activities depends, in turn, on the need as reflected in

growth in demand, and on financial incentives. There is a crucial interdependence among these factors. It is beyond the scope of this report, however, to comment on this complex but decisive interrelationship.

## HISTORICAL DISCOVERY RECORD FOR NATURAL GAS AND NATURAL GAS LIQUIDS

### Methods Same as Used by AGA

The methods and concepts employed in estimating the proved reserves of natural gas and natural gas liquids were essentially the same as those employed by the AGA Committee on Reserves as previously described, and the estimates reported in Tables II and III are in essential agreement with estimated reserves reported by the American Gas Association. As has previously been described for crude oil, however, these reserves have been converted to total discoveries rather than remaining reserves, and have been tabulated according to the discovery years of the individual fields in accordance with the request of the U. S. Department of the Interior.

### Comparison with AGA Estimates for Gas

Insofar as the Committee is aware, no such previous study as the PAW study for crude oil has been reported for either natural gas or natural gas liquids in which estimated recoveries were tabulated according to discovery years of the individual

fields and reservoirs. However, some insight into the growth in recovery estimates for these materials may be obtained by comparison of the present estimates with estimated recoveries assigned by the AGA to new fields and new pools. Some of the factors that have contributed to the continued large upward revisions of estimated recoveries of crude oil, such as secondary recovery and certain other improved recovery methods, are not applicable to natural gas. Also, the natural expulsion forces are, in general, more efficient in recovery of gas than oil. Thus the theoretical limit of gas-in-place would be reached sooner than in oil and would tend to restrict the magnitude of future upward revisions.

In spite of these limitations, upward revisions of recovery estimates for both natural gas and natural gas liquids have resulted from technological improvements. Such factors, for example, as well stimulation and well fracturing have contributed materially to greater recovery of natural gas, and advances are continuously being made in the recovery of natural gas liquids from the gas processed. Upward revisions stemming from extension drilling and more complete production history are equally applicable to gas and oil.

Estimates reported annually by the American Gas Association beginning in 1947 show that the amount added to reserves of natural gas through extensions and revisions has, on the average, exceeded by slightly more than twofold the reserves credited annually to discoveries in new fields and new pools as estimated at the end of the discovery years. For the 13-year period 1947-59, inclusive, 67.3 trillion cubic feet of gas were credited to newly discovered fields and pools whereas, during this same interval, 149.5 trillion cubic feet were added to reserves through extensions and revisions. Although the amount added by extensions and revisions relative to the additions from new fields and new pools is not as great in the case of gas as in the case of crude oil, it has nevertheless been appreciable. For the years 1947-1954, inclusive, the AGA showed a total of 35.5 trillion cubic feet of gas assigned to newly discovered fields and pools. The present report, based on data available at the end of 1959, assigns 95.8 trillion cubic feet to the fields discovered in those years, an increase of 2.7 fold. It must be concluded, therefore, that the growth in estimated recovery from a field as heretofore described in detail for oil fields is applicable to gas fields also, though perhaps not to so great a degree.

## Comparison with AGA Estimates for Natural Gas Liquids

In the case of natural gas liquids, the annual reports of the American Gas Association show a total of 1.12 billion barrels added to reserves through discoveries in new fields and new pools over the interval from 1947-1959, inclusive. During this same interval, 5.91 billion barrels were added to reserves through extensions and revisions. The ratio of the amount added through extensions and revisions to the quantity attributed to new fields and new pools was 5.27. This increase is quite comparable to that previously described for crude oil. For the period 1947-1954, the AGA showed a total of 614 million barrels discovered in new fields and new pools. The present report assigns 2.8 billion barrels to the fields discovered in those years, an increase of 4.2 fold. It may be concluded, therefore, that in the case of natural gas liquids, the magnitude and duration of the increase in estimated recoveries as a result of extensions and revisions are comparable to the experience for crude oil. The large increase undoubtedly reflects additional extraction plants, increased efficiency of existing plants, emphasis in recent years on pressure maintenance and cycling of gas condensate reservoirs, and increases in the estimated reserves of natural gas from which the liquids are extracted.

## Historical Tabulations Do Not Show Discovery Trends

It may be concluded from the preceding considerations that future additions to estimated recoveries of natural gas and of natural gas liquids may be expected from fields already discovered. As in the case of crude oil, therefore, the historical tabulations presented in Tables II and III should not be construed as representing an accurate record of discovery trends. Furthermore, the conclusions heretofore reached with respect to crude oil may be considered applicable also to natural gas and natural gas liquids.

### CRUDE OIL PRODUCTIVE CAPACITY

The productive capacity of crude oil in the United States on January 1, 1960, is estimated to have been 10,585,000 barrels a day, including a shut-in capacity of 163,000 barrels a day in the Elk Hills field in California. Details by PAD districts are shown in Table IV and recapitulated below:

<u>District</u>	<u>Crude Oil Productive Capacity (Thousand Barrels Daily)</u>
1. East Coast	29
2. Mid-Continent	1,555
3. Gulf Coast	7,331
4. Rocky Mountain	664
5. West Coast	<u>1,006</u>
Total United States	10,585

As in prior reports, it must be emphasized that the estimates of productive capacity deal only with the quantities that could be produced from known fields through existing wells without regard to possible limitations of transportation or other facilities. The known limitations of such additional facilities make it evident that the full amount of oil producible in the United States could not be made available to markets on short notice.

#### Changes in Productive Capacity

A comparison of the present estimate of crude oil productive capacity with prior estimates by the National Petroleum Council is set forth in Table V. The present study indicates an increase of productive capacity since January 1, 1957, of 718,000 barrels a day, representing an annual increase during the past three years of 238,000 barrels a day. The productive capacity declined in Districts 1, 2, and 5 and increased only slightly in District 4. The annual increase in District 3 was less than half the rate of increase during the prior 30 months from July 1, 1954, to January 1, 1957, and was the lowest rate of increase since this series of studies began in 1951. The reduced rate of increase in productive capacity reflects the reduction in drilling that has taken place since 1956. The number of wells drilled in the

United States increased rapidly and continuously from 1951 through 1956, reaching a peak in the latter year, but thereafter has declined substantially. In spite of the reduction in drilling and reduced rate of increase in productive capacity, there was a substantial net gain of productive capacity relative to production, representing a net increase of spare productive capacity from 1957 to 1960.

#### Projected Productive Capacity for 1961 and 1962

The productive capacity stated in this report could not be sustained for more than a brief period without further drilling. Production depletes reserves and thereby continuously reduces productive capacity unless the reduction is offset by development of new reserves or stimulation of recovery through pressure maintenance or other measures. The rate of decline of productive capacity varies from reservoir to reservoir, being rapid in some and slow in others, but in any reservoir the productive capacity eventually reaches zero when the reserve is depleted.

A projection of productive capacity requires, therefore, an estimate of the rate of decline of existing capacity, which depends on the rate of production, and a further estimate of the rate of addition to capacity through drilling of new wells and

other measures. In order to arrive at useful and informative estimates, the Committee has chosen not to make speculative predictions of future drilling but, instead, has undertaken to comply with this part of its assignment on the following basis:

1. An estimate has been made of the decline in productive capacity from the January 1, 1960, level under the dual assumptions that

- a. production after January 1, 1960, is at the capacity rate of 10,585,000 barrels a day, and
- b. no drilling or stimulation measures take place after January 1, 1960.

2. An estimate has been made of the number of wells that would have to be drilled annually to maintain productive capacity until January 1, 1962, if production after January 1, 1960, were at the capacity level of 10,585,000 barrels a day.

#### Decline in Productive Capacity with No Drilling

Because the industry has had no experience with a condition of no drilling, and for the further reason that production in some areas has not been at or even near capacity in many years, the estimate of the decline in productive capacity without drilling should be considered as an approximation only. Subject to these reservations, the Committee has estimated that the productive capacity without drilling would decline from its January 1, 1960,

level of 10,585,000 barrels a day to 9,694,000 barrels a day by January 1, 1961, and to 8,905,000 barrels a day by January 1, 1962. These levels represent declines of 891,000 barrels a day during the first year and 789,000 barrels a day during the second year. Details of the estimates of the declines by PAD districts are shown in Table IV.

#### Estimated Drilling Required to Maintain Productive Capacity

If conditions of the recent past governing drilling were to continue in the future, the district subcommittees and working groups have estimated it would be necessary to drill about 20,000 to 25,000 oil wells a year to maintain until January 1, 1962, the January 1, 1960, productive capacity of 10,585,000 barrels a day. This assumes production at capacity after January 1, 1960.

Experience in the United States during the last ten years has shown that of the total wells drilled only slightly more than half have been successfully completed as oil wells. The remainder are gas wells, dry holes, and service wells. In order, therefore, to obtain the oil wells required to maintain productive capacity if production were at capacity rates, it would be necessary to drill about 40,000 to 50,000 total wells a year, including a sufficient number of wildcat wells to provide the required locations. To provide a comparison of this estimate with

prior experience, it might be noted that during the past ten years an average of about 51,000 total wells have been drilled annually in the United States, including about 11,000 wildcat wells and 26,000 oil wells.

The estimate of the number of wells required to maintain productive capacity is of necessity an approximation and has therefore been expressed as a range. It implicitly assumes the continuation of exploration at the level required to support the necessary wildcat drilling. It also assumes that during the period under consideration there will be no material change from the recent past with respect to geographic distribution of wells, quality of reserves developed, proportion of productive oil wells to total wells, or spacing of wells, and that future oil wells will, on the average, develop new productive capacity at about the same rate as the wells heretofore drilled.

Should an emergency actually arise that would require maintenance of production at a capacity level, it would be important to recognize that the drilling of new wells is only one element of the maintenance of capacity. The number of wells required could be modified materially by changes in well spacing, by geographic shifts in drilling from less productive to more prolific areas, and by the employment of other measures for stimulation of production, such as injection of water, gas,

or other fluids. Steel and other essential materials would be required not only for wells but for production equipment and other facilities for both maintenance of production and development of new productive capacity to offset the decline of existing fields. These additional requirements for maintenance of productive capacity were considered not to fall within the scope of the assignment to this Committee and have therefore not been studied. They are mentioned here solely because of their importance with respect to maintenance of productive capacity.

In arriving at the estimate of the number of wells required to maintain productive capacity, it was noted that the district subcommittees estimated that in several states the number of wells likely to be drilled during 1960 and 1961 would not be adequate to maintain productive capacity at the January 1, 1960, level. It has been assumed that the deficiencies in these states could be compensated for by drilling elsewhere in the United States, though not necessarily within the same districts.

#### PRODUCTIVE CAPACITY OF NATURAL GAS

The productive capacity of natural gas in the United States on January 1, 1960, is estimated to have been 71,504 million cubic feet per day. A summary by PAD districts is shown below:

<u>District</u>	<u>Natural Gas Productive Capacity (Thousands of Cubic Feet Daily at 14.65 psia and 60° F.)</u>
1. East Coast	990,300
2. Mid-Continent	8,203,600
3. Gulf Coast	58,121,200
4. Rocky Mountain	2,327,000
5. West Coast	<u>1,862,000</u>
Total United States	71,504,100

Natural gas commonly occurs in solution in crude oil or associated with crude oil as well as in reservoirs that contain no oil. The above estimate of productive capacity is the total of the individually estimated productive capacities of non-associated, associated, and dissolved gas.\* Productive capacities by PAW districts by type of gas are shown in Table VI.

#### Maximum Requirement for Natural Gas

The Committee, as a part of its study, made a determination of the peak-day requirement for natural gas from all sources

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\* The Committee has adopted the definitions used by the Committee on Natural Gas Reserves of the American Gas Association, as follows:

- (a) Non-associated gas: free gas not in contact with crude oil in the reservoir; and free gas in contact with oil where the production of such gas is not significantly affected by the production of crude oil.
- (b) Associated gas: free gas in contact with crude oil in the reservoir where the production of such gas is significantly affected by the production of crude oil.
- (c) Dissolved gas: gas in solution with crude oil in the reservoir.

and for all uses during the year 1959. This was found to be 45,677 million cubic feet. This figure should be kept in mind in considering the productive capacity of natural gas from the various sources as set out hereafter. It should be noted that approximately one-fourth of the gas produced on the peak day in 1959 was produced along with crude oil, and the remainder came from non-associated reservoirs. The productive capacity of natural gas from non-associated reservoirs alone is slightly in excess of the estimated peak-day requirements for all types of gas.

#### Gas from Non-Associated Reservoirs

The productive capacity of natural gas from non-associated reservoirs was defined by the Coordinating Subcommittee for Natural Gas and Natural Gas Liquids Reserves and Availability as follows:

"The maximum sustainable rate at which a field can be produced under present conditions without specific regard to production equipment, pipe line capacities, or established allowables."

The productive capacity of all gas wells completed in non-associated reservoirs in the United States on January 1, 1960, was estimated to be 50,791 million cubic feet per day. This was slightly greater than the peak-day requirement in 1959, estimated by the Committee to total 45,677 million cubic feet from all sources.

### Gas Produced with Oil

The productive capacity of natural gas produced with oil depends on the rate of oil production. The Committee has estimated that if crude oil were produced at the estimated January 1, 1960, capacity rate of 10,585,000 barrels a day, the quantity of gas produced with that oil would have been 20,713 million cubic feet per day, of which 15,406 million cubic feet would have been gas dissolved in the oil. The remaining 5,307 million cubic feet represents gas that would have been produced from associated gas reservoirs. It should be particularly noted that the rate of production of dissolved and associated gas depends on the rate of oil production. In Table VI, which shows the productive capacity for the three types of gas, all estimates of productive capacity for associated and dissolved gas are based on the supposition that oil is being produced at the capacity rates shown in Table IV.

### Gas in Cycled, Shut-In, and Storage Reservoirs

The estimated productive capacity includes gas from fields which are now being cycled, as well as gas from fields which are not at present producing but are capable of production. The estimated productive capacity does not, however, include any gas which may be available from storage reservoirs.

## Productive Capacity is Not Availability

The productive capacity of natural gas was estimated on the same conceptual basis as was used to estimate the productive capacity of crude oil. That is, it reflects the capacity of the gas and oil reservoirs and is a measure of the amount that could be produced from existing wells without regard to limitations of markets, transportation, and processing facilities.

It is evident from the foregoing considerations that the productive capacity of natural gas as used in this report is in no sense a measure of the current availability of gas for consumption, and it should not be so construed. Presently available facilities limit the use of gas that could be produced. Any increase in daily production would require adequate markets and the installation of additional pipeline, compressor, and other facilities, with allowance for the time and material required for such installation.

The productive capacity of natural gas must be viewed in an entirely different light from the productive capacity of crude oil. Oil can be stored in tanks near the area of production and can then be moved to refinery or market when needed. On the other hand, gas after leaving the well can only be carried through pipelines to the market. The storage of gas is quite expensive and requires much advance planning and construction since the

principal containers are underground reservoirs. In actual practice, the storage of gas has been largely confined to the storage of limited quantities in natural underground reservoirs near the market to improve the load factor of the pipelines. This basic difference must be kept in mind in evaluating the estimate of productive capacity contained herein.

As pointed out above, part of the total productive capacity of natural gas is gas that would be produced with oil if oil were being produced at capacity. If oil were ever to be produced at such rates, additional facilities and markets would have to be provided to avoid venting part of this gas.

Another limitation on the full use of the daily volumes of natural gas estimated as producible is the load factor of the existing or additional markets to be served. In other words, one cannot multiply the estimated capacity of 71,504 million cubic feet as of January 1, 1960, by 365 and thereby obtain the annual amount that could be produced from this daily quantity. Such a quantity must be multiplied by the load factor of the market to obtain the annual amount. The Committee found that the overall load factor (the ratio of the average daily production to the peak day production) of gas production in the United States is about 70%.

The producibility of gas from a reservoir is not directly proportional to the volume of gas contained in the reservoir, but

depends on the underground physical characteristics. Gas could not be produced indefinitely at the maximum rates estimated in this report because those reservoirs that have higher productive capacities per unit of gas reserve would be rapidly depleted.

Projected Capacity for 1961 and 1962

In compliance with its assignment, the Committee has estimated the decline in capacity that would take place if production were maintained at the average 1959 level and there were no drilling after January 1, 1960. The resultant capacities on January 1, 1961, and January 1, 1962, were estimated to be as follows:

Projected Productive Capacity of Natural Gas  
(Millions of Cubic Feet Per Day)

	<u>From Non-associated Reservoirs</u>	<u>Dissolved and Associated Gas Produced with Crude Oil</u>	<u>Total</u>
January 1, 1960	50,791	20,713	71,504
January 1, 1961	48,293	19,496	67,789
January 1, 1962	45,914	18,411	64,325

The projected productive capacities are shown by PAD districts and by types of gas in Table VI.

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In summation, the Committee finds that while the productive capacity of natural gas from non-associated reservoirs appears to be sufficient to supply the current demand through 1961, there

is available in addition a large quantity of gas produced with crude oil. At 1959 rates of oil production, there was produced along with the oil some 11,624 million cubic feet per day of gas. The difference between this value (11,624) and the value of 20,713 for January 1, 1960, consists of gas which can only be produced by increasing the rate of oil production throughout the United States to the maximums set out in Table IV. Under these circumstances, no value of productive capacity of natural gas should be taken from or deduced from this report, unless the quantity of gas produced with oil is separately determined and related to the contemporaneous rate of oil production.

A further aspect of the productive capacity of natural gas should be kept in mind. The fact that this report shows that total productive capacity exceeds the current demand does not mean that this excess is distributed uniformly throughout the United States or is uniformly available to all gas companies and customers or that no section of the United States will experience any shortage. To illustrate, on January 1, 1960, the productive capacity from non-associated reservoirs in District 3 was 41,892 million cubic feet. When there is added to this 8,180 million cubic feet currently being produced with oil, the total current capacity is found to be 50,162 million cubic feet per day. The peak day production in District 3 for 1959 was approximately

34,692 million cubic feet. This indicates an excess, in District 3, as of January 1, 1960, of 15,470 million cubic feet per day with the oil wells being produced at 1959 rates. The comparable excess for the United States is 16,738 million cubic feet per day. This indicates that substantially all of the current excess capacity is located in District 3.

Such excess, to supply increased demands or to offset anticipated decline in other areas, would have to be transported to such areas by pipelines either existing or to be provided.

#### PRODUCTIVE CAPACITY OF NATURAL GAS LIQUIDS

Natural gas liquids are those hydrocarbon liquids that, in the reservoir, are either in gaseous form or in solution in crude oil. At the surface, they are recovered as liquids by separation from natural gas by such processes as condensation or absorption, in field separators, scrubbers, gasoline plants, or cycling plants. Natural gasoline, condensate, and liquefied petroleum gases fall in this category. Since natural gas liquids are not produced as such from underground reservoirs but become available solely by separation from natural gas, their availability depends directly on the rate of production of gas and oil and requires the existence of adequate separation or extraction equipment to effect their removal from the produced gas.

In prior reports prepared for the National Petroleum Council, the estimated availability of natural gas liquids has been restricted to the volumes that could be recovered through existing plants and other equipment from the gas actually being produced.

Such is not the case in the present study. In an effort to appraise more fully the total potential productive capacity of petroleum liquids in the United States, the Committee has estimated the capacity of natural gas liquids on the basis of the volumes that could be recovered if both crude oil and natural gas were being produced at the full capacity rates shown elsewhere in this report. On this basis, the maximum productive capacity of natural gas liquids has been estimated to be as follows:

Maximum Productive Capacity of Natural Gas Liquids  
(Barrels Daily)

	<u>From Gas From Non-associated Reservoirs</u>	<u>From Dissolved Gas and Gas From Associated Reservoirs Produced With Crude Oil</u>	<u>Total</u>
January 1, 1960	938,800	860,800	1,799,600
January 1, 1961*	895,100	824,500	1,719,600
January 1, 1962*	854,100	793,300	1,647,400

\* Projected on basis of no drilling after January 1, 1960.

The estimated productive capacities are shown by PAD districts and by types of gas from which separated in Table VII. Productive Capacity is Not Availability

It must be recognized that the preceding estimate is not an actual availability, for the plants do not now exist that would be required to recover these liquids, and neither gas nor oil is being produced at rates even closely approaching capacity production. However, as a measure of the volume that could be made available under all-out conditions, the estimate should be useful in appraisal of this country's total hydrocarbon resources. The actual future quantity of natural gas liquids producible at any given time will depend on the volumes of gas and oil being produced and on the installation of the necessary extraction facilities. The remarks previously made with respect to natural gas productive capacity concerning market, load factor, and the interrelation of a large part of the capacity to the rate of oil production are also applicable to natural gas liquids.

## TABLES AND EXHIBITS

TABLE	I	Estimated Discoveries of Crude Oil Now Assigned to Fields and Reservoirs Discovered in Various Years
TABLE	II	Estimated Discoveries of Natural Gas Now Assigned to Fields and Reservoirs Discovered in Various Years
TABLE	III	Estimated Discoveries of Natural Gas Liquids Now Assigned to Fields and Reservoirs Discovered in Various Years
TABLE	IV	U. S. Crude Oil Productive Capacity
TABLE	V	Changes in Crude Oil Productive Capacity - United States (1951-1960)
TABLE	VI	Maximum Productive Capacity of Natural Gas in the United States
TABLE	VII	Maximum Productive Capacity of Natural Gas Liquids in the United States

NOTE: These seven tables should be used only after a review and full understanding of the text on discoveries and productive capacity of crude oil, natural gas, and natural gas liquids.

EXHIBITS: Various letters from the U. S. Department of the Interior requesting this National Petroleum Council study.

TABLE I

SUMMARY OF ESTIMATED DISCOVERIES  
OF CRUDE OIL NOW ASSIGNED TO  
FIELDS DISCOVERED IN YEARS SHOWN  
(Thousands of Barrels)

<u>FIELDS AND RESERVOIRS DISCOVERED</u>	<u>DISTRICT 1</u>	<u>DISTRICT 2</u>	<u>DISTRICT 3</u>	<u>DISTRICT 4</u>	<u>DISTRICT 5</u>	<u>TOTAL U.S.</u>
Through 1919	2,012,106	5,860,591	3,584,041	611,766	5,298,771	17,367,275
In 1920	3,654	693,723	224,703	41,545	1,451,200	2,414,825
1921	3,327	395,987	1,589,462	95,165	868,000	2,951,941
1922	2,756	198,132	905,010	142,707	188,300	1,436,905
1923	1,858	533,067	324,305	40,788	440,700	1,340,718
1924	2,223	294,019	158,636	41,017	286,250	782,145
1925	2,368	74,289	282,426	27,475	154,200	540,758
1926	3,376	717,849	1,979,065	34,772	190,000	2,925,062
1927	4,000	587,883	690,606	184,285	161,441	1,628,215
1928	2,361	863,484	879,642	85,306	634,011	2,464,804
1929	4,500	490,985	1,841,524	4,421	66,425	2,407,855
1930	2,195	160,819	6,247,674	183,899	58,500	6,653,087
1931	730	301,802	1,667,632	2,300	535,929	2,508,393
1932	460	78,185	179,951	184,000	88,400	530,996
1933	740	256,909	348,068	523,270	84,390	1,213,377
1934	1,000	264,262	1,950,307	4,291	237,800	2,457,660
1935	1,500	670,347	2,173,310	22,251	43,510	2,910,918
1936	2,119	86,158	2,157,263	10,396	1,245,700	3,501,636
1937	8,900	824,863	2,080,220	133,576	283,060	3,330,619
1938	1,360	887,709	1,737,246	5,520	894,465	3,526,300
1939	990	248,961	902,552	0	111,635	1,264,138
1940	1,120	519,670	2,274,199	8,180	35,290	2,838,459
1941	1,230	583,007	895,020	0	483,071	1,962,328
1942	1,210	179,892	759,727	367,220	28,348	1,336,397
1943	10,740	409,913	834,063	171,370	47,635	1,473,721
1944	700	265,231	1,070,638	334,231	170,120	1,840,920
1945	2,365	137,209	1,351,973	17,992	193,565	1,703,104
1946	1,170	513,968	650,699	157,621	77,778	1,401,236
1947	2,262	261,022	757,813	17,581	236,445	1,275,123
1948	1,440	138,486	2,132,397	154,797	164,431	2,591,551
1949	900	201,609	2,049,924	179,753	243,790	2,675,976
1950	1,400	158,600	1,914,883	102,262	47,140	2,224,285
1951	860	239,964	856,574	199,184	60,598	1,357,180
1952	870	296,507	805,179	212,548	92,591	1,407,695
1953	740	192,347	1,238,519	181,517	51,437	1,664,560
1954	913	236,271	1,069,756	140,144	67,426	1,514,510
Total	<u>2,090,443</u>	<u>18,823,720</u>	<u>50,565,007</u>	<u>4,623,150</u>	<u>15,322,352</u>	<u>91,424,672</u>

TABLE II

SUMMARY OF ESTIMATED DISCOVERIES  
OF NATURAL GAS NOW ASSIGNED TO  
FIELDS DISCOVERED IN YEARS SHOWN  
(Millions of Cubic Feet at 14.65 psia and 60° F.)

<u>FIELDS AND RESERVOIRS DISCOVERED</u>	<u>DISTRICT 1</u>	<u>DISTRICT 2</u>	<u>DISTRICT 3</u>	<u>DISTRICT 4</u>	<u>DISTRICT 5</u>	<u>TOTAL U.S.</u>
Through 1919	14,667,195	8,211,603	45,896,331	1,398,037	5,603,672	75,776,838
In 1920	347,549	489,775	123,524	98,200	1,003,884	2,062,932
1921	170,056	426,292	1,522,276	49,300	1,075,447	3,243,371
1922	96,456	28,345,781	5,778,566	295,807	129,907	34,646,517
1923	121,400	817,594	985,516	5,970	399,016	2,329,496
1924	73,227	375,695	925,095	21,074	307,001	1,702,092
1925	154,242	470,942	972,536	107,490	36,711	1,741,921
1926	376,980	797,912	3,017,606	586,446	242,415	5,021,359
1927	131,867	1,290,379	11,879,049	368,717	89,389	13,759,401
1928	53,494	1,719,515	1,199,573	173,619	2,202,533	5,348,734
1929	30,503	422,870	10,266,772	77,986	66,137	10,864,268
1930	220,024	677,677	6,171,085	193,860	123,783	7,386,429
1931	70,526	348,346	2,677,631	99,337	1,232,777	4,428,617
1932	101,753	193,792	2,940,935	63,820	448,579	3,748,879
1933	205,910	479,910	3,242,882	637,200	118,857	4,684,759
1934	56,291	565,316	9,271,822	2,554	489,663	10,385,646
1935	132,624	544,620	12,835,403	138,996	56,063	13,707,706
1936	906,722	311,823	11,568,902	1,900	4,530,413	17,319,760
1937	87,321	727,449	13,278,961	119,251	1,618,289	15,831,271
1938	52,152	543,560	15,748,926	836,450	1,167,650	18,348,738
1939	67,456	359,294	8,940,849	-	1,318,281	10,685,880
1940	65,498	539,586	10,266,150	1,887	106,727	10,979,848
1941	100,545	652,235	7,440,076	1,697	487,427	8,681,980
1942	114,798	357,253	6,153,382	130,842	176,356	6,932,631
1943	123,899	646,763	5,844,945	50,199	242,347	6,908,153
1944	136,703	324,889	5,773,062	237,498	339,617	6,811,769
1945	382,174	1,368,709	10,301,137	86,682	291,883	12,430,585
1946	139,109	1,872,688	4,448,526	871,859	187,575	7,519,757
1947	127,432	1,368,182	6,713,607	85,405	197,708	8,492,334
1948	128,948	233,624	7,217,739	365,887	223,053	8,169,251
1949	138,080	819,762	19,299,950	296,519	290,588	20,844,899
1950	179,914	559,562	6,643,119	557,016	213,155	8,152,766
1951	300,102	2,082,168	7,295,957	1,241,286	163,834	11,083,347
1952	88,714	3,862,946	10,606,741	182,218	271,317	15,011,936
1953	160,891	464,021	8,647,190	785,639	313,307	10,371,048
1954	135,632	1,951,974	10,979,493	399,561	170,948	13,637,608
<b>Total</b>	<u>20,446,187</u>	<u>65,224,507</u>	<u>296,875,314</u>	<u>10,570,209</u>	<u>25,936,309</u>	<u>419,052,526</u>

TABLE III  
SUMMARY OF ESTIMATED DISCOVERIES  
OF NATURAL GAS LIQUIDS NOW ASSIGNED TO  
FIELDS DISCOVERED IN YEARS SHOWN  
(Thousands of Barrels)

<u>FIELDS AND RESERVOIRS DISCOVERED</u>	<u>DISTRICT 1</u>	<u>DISTRICT 2</u>	<u>DISTRICT 3</u>	<u>DISTRICT 4</u>	<u>DISTRICT 5</u>	<u>TOTAL U. S.</u>
Through 1919	96,447	121,608	686,082	44,172	282,226	1,230,535
In 1920	3,162	15,496	1,245	-	63,166	83,069
1921	1,451	11,698	32,117	-	74,467	119,733
1922	504	322,993	89,408	-	4,243	417,148
1923	775	18,458	22,437	-	18,449	60,119
1924	356	8,726	17,295	-	12,475	38,852
1925	1,104	3,799	23,501	-	909	29,313
1926	3,433	28,729	54,877	4,985	9,090	101,114
1927	1,100	33,477	186,250	471	4,376	225,674
1928	362	54,822	26,062	-	88,447	169,693
1929	192	7,322	205,649	-	1,495	214,658
1930	1,591	11,352	720,102	480	6,644	740,169
1931	143	9,367	84,004	1,118	59,972	154,604
1932	865	5,775	46,622	-	15,623	68,885
1933	137	16,055	17,516	25,461	4,328	63,497
1934	171	9,863	294,162	-	21,507	325,703
1935	850	14,590	371,059	8,880	485	395,864
1936	9,374	4,822	211,801	37	69,330 <sup>1</sup>	295,364
1937	171	30,136	331,645	3,190	76,269	441,411
1938	156	34,488	329,966	24,184	58,280	447,074
1939	481	11,123	207,516	-	107,882	327,002
1940	189	22,058	367,659	-	5,291	395,197
1941	504	29,503	231,724	-	14,031	275,762
1942	686	10,184	224,059	22,145	3,492	260,566
1943	686	22,572	135,250	-	2,865	161,373
1944	897	10,593	206,232	5,699	11,164	234,585
1945	4,284	19,167	281,321	8	10,400	315,180
1946	1,041	67,538	150,405	10,108	7,888	236,980
1947	991	36,417	177,488	-	3,513	218,409
1948	850	5,688	460,212	1,965	11,918	480,633
1949	625	29,721	453,838	9,147	16,425	509,756
1950	555	20,849	200,237	12,826	3,010	237,477
1951	470	33,177	156,240	9,672	1,094	200,653
1952	487	82,906	243,600	3,782	6,934	337,709
1953	454	10,651	260,092	13,931	960	286,088
1954	914	33,660	263,770	5,333	5,432	309,109
<b>TOTAL</b>	<u>136,458</u>	<u>1,209,383</u>	<u>7,771,443</u>	<u>207,59</u>	<u>1,084,080</u>	<u>10,408,958</u>

TABLE IV

U. S. CRUDE OIL PRODUCTIVE CAPACITY  
(Thousand Barrels Daily)

	<u>Jan. 1, 1960</u>	Projected on Basis of No Drilling After January 1, 1960	
		<u>Jan. 1, 1961</u>	<u>Jan. 1, 1962</u>
District 1	29	26	24
District 2	1,555	1,383	1,235
District 3	7,331	6,772	6,275
District 4	664	587	521
District 5*	843	770	701
Elk Hills Shut-in	<u>163</u>	<u>156</u>	<u>149</u>
Total District 5	1,006	926	850
Total U.S. Excl. Elk Hills Shut-in	10,422	9,538	8,756
Total U.S. Incl. Elk Hills Shut-in	10,585	9,694	8,905

\* Excluding current shut-in capacity at Elk Hills.

TABLE V

CHANGES IN CRUDE OIL PRODUCTIVE CAPACITY - UNITED STATES  
(Thousand Barrels Daily)

	Jan. 1	Jan. 1	July 1	Jan. 1	Jan. 1	Annual Rate of Change (2)			
	<u>1951</u>	<u>1953</u>	<u>1954</u>	<u>1957</u>	<u>1960</u>	<u>1951-53</u>	<u>1953-54</u>	<u>1954-57</u>	<u>1957-60</u>
<u>District</u>									
1. East Coast	54	49	43	37	29	-2	-4	-2	-3
2. Mid-Continent	1,083	1,238	1,380	1,591	1,555	78	95	85	-12
3. Gulf Coast	4,161	4,686	5,224	6,613	7,331	262	359	555	239
4. Rocky Mountain	350	394	561	615	664	22	111	21	16
5. West Coast (1)	<u>1,079</u>	<u>1,098</u>	<u>1,123</u>	<u>1,011</u>	<u>1,006</u>	<u>9</u>	<u>16</u>	<u>-45</u>	<u>-2</u>
Total	<u>6,727</u>	<u>7,465</u>	<u>8,331</u>	<u>9,867</u>	<u>10,585</u>	<u>369</u>	<u>577</u>	<u>614</u>	<u>238</u>

(1) Including Elk Hills. The estimate for Jan. 1, 1960, included Elk Hills at 175,000 barrels daily, of which 163,000 barrels daily was shut in. Prior reports included Elk Hills at 158,000 barrels daily in 1954 and at 87,000 barrels daily for January 1957. The 1957 estimate was reduced because of facility limitations, whereas the 1960 estimate was based on efficient capacity of existing wells irrespective of the limitations of surface facilities

(2) Rates of change influenced slightly by differences in estimates of productive capacity for Elk Hills, as per note (1).

TABLE VI

MAXIMUM PRODUCTIVE CAPACITY OF NATURAL GAS  
IN THE UNITED STATES

(Thousand Cubic Feet Daily at 14.65 psia and 60° F.)

	<u>Non-Associated</u>	<u>Associated</u>	<u>Dissolved</u>	<u>Total</u>
1-1-1960				
PAD Dist. 1	983,200	0	7,100	990,300
2	5,466,900	888,400	1,848,300	8,203,600
3	41,892,600	4,267,800	11,960,800	58,121,200
4	1,720,000	151,000	456,000	2,327,000
5	<u>728,000</u>	<u>0</u>	<u>1,134,000</u>	<u>1,862,000</u>
Total	50,790,700	5,307,200	15,406,200	71,504,100
1-1-1961*				
PAD Dist. 1	711,600	0	5,100	716,700
2	5,436,500	883,200	1,655,600	7,975,300
3	39,861,850	4,004,600	11,349,400	55,215,850
4	1,596,000	132,000	429,000	2,157,000
5	<u>687,000</u>	<u>0</u>	<u>1,037,000</u>	<u>1,724,000</u>
Total	48,292,950	5,019,800	14,476,100	67,788,850
1-1-1962*				
PAD Dist. 1	580,500	0	4,100	584,600
2	5,396,900	880,000	1,470,500	7,747,400
3	37,830,625	3,731,300	10,829,000	52,390,925
4	1,459,000	119,000	403,000	1,981,000
5	<u>647,000</u>	<u>0</u>	<u>974,000</u>	<u>1,621,000</u>
Total	45,914,025	4,730,300	13,680,600	64,324,925

\* Projected on basis of no drilling after January 1, 1960.

NOTES:

- (i) This statement does not include any gas available from storage reservoirs.
- (ii) This statement does include gas available from reservoirs being cycled.

TABLE VII

MAXIMUM PRODUCTIVE CAPACITY OF NATURAL GAS LIQUIDS  
IN THE UNITED STATES

(Thousand Barrels Daily)

	PAD Districts					<u>Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
1-1-1960						
Non-Associated	10.2	70.2	843.4	15.0	-	938.8
Associated	-	13.3	125.7	2.0	-	141.0
Dissolved	-	<u>79.1</u>	<u>532.7</u>	<u>20.0</u>	<u>88.0</u>	<u>719.8</u>
Total	10.2	162.6	1,501.8	37.0	88.0	1,799.6
1-1-1961*						
Non-Associated	7.5	70.1	803.5	14.0	-	895.1
Associated	-	13.3	116.2	2.0	-	131.5
Dissolved	-	<u>71.5</u>	<u>521.5</u>	<u>20.0</u>	<u>80.0</u>	<u>693.0</u>
Total	7.5	154.9	1,441.2	36.0	80.0	1,719.6
1-1-1962*						
Non-Associated	6.3	69.1	764.7	14.0	-	854.1
Associated	-	13.3	108.3	2.0	-	123.6
Dissolved	-	<u>65.1</u>	<u>512.6</u>	<u>19.0</u>	<u>73.0</u>	<u>669.7</u>
Total	6.3	147.5	1,385.6	35.0	73.0	1,647.4

\* Projected on basis of no drilling after January 1, 1960.

EXHIBIT A

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF THE SECRETARY  
WASHINGTON 25, D. C.

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September 30, 1959

Dear Mr. Hallanan:

During World War II the Petroleum Administration for War prepared a report on the proved reserves of crude oil in the United States arranged according to the year of discovery of each field. This report proved to be very valuable in appraising the trend of results obtained from exploration, particularly through 1940, or 4 years prior to the last reserve estimate made as of the end of 1944.

In its efforts to appraise the long-term petroleum supply and demand position of the United States, the Government needs a revision and up-dating of the PAW crude oil reserves report arranged according to the year of discovery. The API estimates of proved crude oil reserves published each year are an accurate and useful inventory of recoverable oil but they are not compiled to indicate the rate of discovery of new sources of supply. It is suggested that the API estimates of remaining proved reserves as of December 31, 1959, be used as the base for developing and compiling the desired report. It is further suggested that 1954 be used as the terminal year in this report, as discoveries subsequent to that year may not be developed enough to provide an adequate estimate of reserves as of December 31, 1959. The discovery and reserve data, as compiled in final form for the report, should be shown by PAW districts, by years, as in the PAW report published in "History of the Petroleum Administration for War," pages 442-3.

In collecting and compiling data for its report, PAW included the drilled and undrilled proved acreage underlain by the estimated proved reserves. If these acreage data can be included in the desired report, they will be of significant value to the Government.

It is, therefore, requested that the National Petroleum Council prepare a report of proved crude oil reserves by years through 1954, using the API estimates of crude oil reserves as of December 31, 1959 as a base, and crediting such reserves back to the year of discovery, substantially as was done by PAW in World War II. It is also requested that the drilled and undrilled proved acreage data as of December 31, 1959, be included, if feasible.

Sincerely yours,

(Sgd) Elmer F. Bennett

Acting Secretary of the Interior

Mr. Walter S. Hallanan  
Chairman, National  
Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

EXHIBIT B

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF THE SECRETARY  
WASHINGTON 25, D. C.

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December 22, 1959

Dear Mr. Hallanan:

This is in reply to your letter of December 14, 1959, wherein you requested clarification of the Department's request of September 30, 1959 to the National Petroleum Council for a report on proved oil reserves, with respect to use of API reserves data.

It was not the intent to stipulate the use of API reserve data in the preparation of the requested report. On the contrary, use by the NPC committee of all sources of information, which in its judgment are suitable for this purpose, will be completely acceptable to the Department.

The suggested use of API reserves data reflected a desire to avoid unnecessary duplication of effort within the petroleum industry and to recognize the widespread acceptance of API reserves data.

Sincerely yours,

(sgd) Fred G. Aandahl

Asst. Secretary of the Interior

Mr. Walter S. Hallanan  
Chairman, National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

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EXHIBIT C

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF OIL AND GAS  
WASHINGTON 25, D. C.

February 5, 1960

Mr. Walter S. Hallanan  
Chairman, National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

Dear Mr. Hallanan:

Your letter of February 2, 1960 requested determination by the Department of the Interior of the basic geographical areas desired for reporting the distribution of reserves in the proposed report by the National Petroleum Council on proved crude oil reserves in the United States.

In Mr. Bennett's letter of September 30, 1959, it was stated that the reserve data, as compiled in final form for the report, should be shown by PAW Districts, by years, as in the PAW report published in "History of the Petroleum Administration for War," pages 442-3. It will not be necessary, therefore, to report the discovery and reserve data by individual fields.

The basic data compiled for the PAW report have been retained in the National Archives, and are available for reference by members of your committee. For the information and guidance of your committee, I enclose a brief description of these data. It appears that an up-dating of the PAW report, insofar as compilation of fields by year of discovery is concerned, involves an addendum covering the fields discovered during the 10-year period 1945 - 1954. The reserve data for the older fields must be revised, however, to reflect production, extensions and revisions since January 1, 1945.

The staff of the Office of Oil and Gas will be happy to explore with members of your committee the details involved in the proposed NPC reserve report.

Sincerely yours,

(sgd) M. V. Carson, Jr.

M. V. Carson, Jr.  
Director

EXHIBIT D

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF THE SECRETARY  
Washington 25, D. C.

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March 9, 1960

Dear Mr. Hallanan:

Since 1947 the National Petroleum Council has prepared a series of reports on petroleum productive capacity of the United States in response to requests from the Department of the Interior. These reports have proved very useful to the Government in its efforts to appraise the domestic petroleum supply position of the Nation, a matter of prime importance to our national security. They have also been widely used and accepted as authoritative by the petroleum industry.

The latest report in this series is the Report of the National Petroleum Council Committee on Petroleum Productive Capacity under the chairmanship of L. F. McCollum, dated October 3, 1957. This report presented productive capacity data as of January 1957 and discussed important developments affecting recent trends in production and in capacity to produce.

Significant changes have occurred during the past 3 years, both in total productive capacity and in its distribution by PAD Districts. It is therefore requested that the National Petroleum Council prepare a report showing the productive capacity of the United States, both of crude oil and of natural gas liquids, as of January 1960, with projections for 1961 and 1962. In order that these data may be most useful, the productive capacity should be defined in terms of sustainability without drilling, for a given period such as 1 year, or alternatively, in terms of the estimated rate of decline in productive capacity during such period.

For purposes of Civil Defense planning, capacity information by States as well as by PAD Districts would have significant value to the Government. It is hoped that the capacity data by States can be made available to Government for such use.

It is requested that the National Petroleum Council make a productive capacity study as outlined above and report thereon, including such comments, conclusions, and recommendations as it may deem appropriate.

Sincerely yours,

(Sgd) Elmer F. Bennett

Under Secretary of the Interior

Mr. Walter S. Hallanan  
Chairman, National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

EXHIBIT E

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF THE SECRETARY  
Washington 25, D. C.

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March 17, 1960

Dear Mr. Hallanan:

The National Petroleum Council is undertaking the preparation of a report of proved crude oil reserves by years through 1954, in accordance with the request of September 30, 1959, and letters dated December 22, 1959 and February 5, 1960, which defined the scope of the study.

It is requested that the Council expand the study and prepare a report of proved reserves of natural gas and of natural gas liquids, compiled insofar as practicable on the same basis as the report of proved crude oil reserves.

Sincerely yours,

(Sgd) Elmer F. Bennett

Under Secretary of the Interior

Mr. Walter S. Hallanan  
Chairman, National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

EXHIBIT F

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
OFFICE OF THE SECRETARY  
Washington 25, D. C.

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March 17, 1960

Dear Mr. Hallanan:

This supplement to your letter of March 9, 1960, requests that the National Petroleum Council also undertake a study of the availability of natural gas upon the same basis as that outlined for crude oil and natural gas liquids.

Sincerely yours,

(Sgd) Elmer F. Bennett

Under Secretary of the Interior

Mr. Walter S. Hallanan  
Chairman  
National Petroleum Council  
1625 K Street, N. W.  
Washington 6, D. C.

