U. S. Crude Petroleum Reserve Productive Capacity

Report Submitted on
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to the

NATIONAL PETROLEUM COUNCIL
1625 K Street, N. W.
WASHINGTON 6, D. C.

Ponca City, Oklahoma
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MR. WALTER S. HALLANAN
Chairman of National Petroleum Council
Washington, D. C.

DEAR MR. HALLANAN:

Transmitted herewith is the report of the National Petroleum Council Committee on Petroleum Reserve Productive Capacity.

This report deals with the important matter of the future supply of oil within the United States which is essential to the American standard of living and is a bulwark of our national security. It presents the results of a factual study of the problem of providing a substantial domestic reserve capacity to be available in the event of an emergency.

Given the opportunity to search for oil competitively and with adequate economic incentive, the American petroleum industry will be able to find and develop adequate reserves to meet future normal domestic demands and still have reserve capacity for a national emergency. A thorough examination of past history and present available facts permits no other conclusion. There is a factual basis for confidence and reasonable optimism with regard to the future supply of oil in this country.

If an emergency should occur today, there would be available 700,000 barrels daily of present reserve domestic capacity and 1,000,000 barrels daily which could be diverted from civilian demand by means of rationing. The report further indicates that reserve productive capacity may increase to 1,000,000 barrels daily in the immediate future, which would mean that, including rationing, 2,000,000 barrels daily would be available in an emergency. These figures leave no doubt that a very substantial reserve supply now exists and will continue to exist.

Twice within the past quarter century the American petroleum industry has dispelled fears of shortages by creating a substantial margin of reserve productive capacity. There is no question that large additional discoveries remain to be made in the United States, and productive capacity can continue to increase. The results in 1948 and 1949 strikingly demonstrated this. As reported by the American Petroleum Institute, additions to proved reserves of petroleum liquids exceeded two billion barrels in 1948. This report is not yet available for 1949, but in its review just now available for 1949, the Oil and Gas Journal estimates that proved reserves increased by 1.25 billion barrels. These large additions have been made although production exceeded two billion barrels of crude oil and natural gas liquids in each year. The rates at which new discoveries will be made and the size of additions to reserve productive capacity will depend on the intensity and magnitude of the industry's exploration and well drilling activities. As these activities involve substantial investments of risk capital, they fluctuate with changes in the relationship between the probable return on investment and the risk involved.

There is no secret formula for finding oil, nor any mystery about the industry's success in the past. The only secret is in the wisdom of our competitive incentive system. The Committee is confident that the petroleum industry will continue to build adequate reserves to meet future needs if a favorable economic climate prevails as in the past.

In conclusion, the report shows that there appears to be no need for commercial scale production of liquid fuels from coal or shale in the next few years. The problem of providing a substantial reserve capacity to produce oil within the United States does not call for any new and untested plans, programs or regulations. The report convincingly demonstrates that a vigorous and healthy American petroleum industry can continue to make available adequate petroleum supplies for peace or war.

Respectfully submitted,

L. F. MCCOLLUM
Chairman, Committee on Crude Petroleum
Reserve Productive Capacity

Report on U. S. Crude Petroleum Reserve Productive Capacity

This report is submitted in compliance with instructions to the Committee that it should "make a factual study of the problem of providing a substantial domestic reserve capacity to be available in the event of an emergency." The study originated from a request by the Honorable J. A. Krug, Secretary of the Interior, to the Chairman of the National Petroleum Council suggesting that the Council give formal consideration to and submit appropriate reports on the problem of providing a substantial domestic reserve productive capacity to be available in the event of an emergency. In authorizing the study, the National Petroleum Council provided that "in view of the competitive aspects of the problem, the Committee should not suggest plans or programs, but should confine its report to findings of facts."

The Committee has considered the general principles involved in providing reserve productive capacity, the factors which created such reserve capacity in the past, and quantitative estimates of available capacity through 1953 based on the report prepared in November 1948 by the Subcommittee on Long-Term Availability of the American Petroleum Institute. The results of the Committee's studies are set forth in subsequent sections of this report.

Crude Oil Production and Reserve Capacity, 1918-49

A review of crude oil production and reserves in the past provides a necessary background for study of the problem of reserve productive capacity for the future. During the last thirty years, tight supply situations developed in 1924-26 and in 1947-48 as the rate of withdrawal from proved reserves approached or exceeded 9.1 per cent annually (See Table 1, Column 4), but following both of these periods the rapid development of new resources soon operated to restore reserve productive capacity.

Concern over the adequacy of domestic petroleum resources increased during the years 1918-24 as the rate of production in relation to proved reserves advanced from 6.1 to about 9.5 per cent a year. During this period there was an increase of 100 per cent in production but of only 20 per cent in proved reserves. (See Table 1.) In 1924 the President created a Federal Oil Conservation Board to consider ways and means of safeguarding the national security through the conservation of oil. The petroleum industry was concerned with the same problem, and undertook its own exhaustive investigation of the oil industry and the petroleum resources of the United States through a Committee appointed by the American Petroleum Institute. The Committee concluded that there was "no imminent danger of exhaustion of the petroleum reserves of the United States" and that a sufficient supply of oil would be "available for national defense and for essential uses in the United States beyond the time when science will limit the demand by developing more efficient use of, or substitutes for, oil or will displace its use as a source of power by harnessing a natural energy." The soundness of those conclusions has been demonstrated by the experience of the past quarter century, during which the domestic oil industry has expanded greatly its production and proved reserves to meet all demands in peace and war. In spite of the production of about 31 billion barrels of oil in the years 1925-49, inclusive, the United States now has much larger proved reserves and enjoys a better relation between reserves and production than it did in 1925.

The oil industry went through a number of changes in the interval 1924-49. Developments during these years fall into three distinct periods: (1) expansion of reserves and productive capacity and the creation of large reserve capacity in the years 1925-41; (2) the period of wartime controls, 1942-46, during which the rapid growth in demand absorbed the reserve productive capacity that had been created during the 1930's because abnormal circumstances kept reserves from increasing materially; (3) the increase in proved reserves and in productive capacity in 1947-49 under the stimulus of increased demand and a higher price.

1925-41

A number of factors contributed to the development of large reserve productive capacity in the period 1925-41. Perhaps the most important development was the introduction of new and improved exploration techniques, particularly geophysics. The application of these techniques resulted in the discovery of many fields, including a large proportion of the major fields that have been found in the entire history of the domestic petroleum industry. Proved reserves increased from 7.5 billion barrels at the beginning of 1925 to 13 billion barrels at the end of 1931. Another factor that operated to create reserve productive capacity was the decline in demand between 1929 and 1932 as a result of the great depression. The combination of these forces reduced the rate of withdrawal on proved crude oil reserves from 10.2 per cent in 1925 to 6.0 per cent in 1932. (See Table 1, Column 4).

Discoveries continued at a high level during the latter part of the 1930's, but production also showed a substantial expansion. By the end of 1940, proved reserves of

crude oil were in excess of 19 billion barrels and the rate of withdrawal was up to 7.3 per cent a year, still far below the levels of the middle 1920's when there had been a fear of shortages. It was officially estimated by the Petroleum Administration for War that in 1940 the maximum efficient crude oil producing rate was 4,745,000 barrels daily, not including the production of natural gas liquids of 152,000 barrels daily. Total domestic capacity at that time exceeded domestic demand by 1,272,000 barrels daily. In other words, domestic demand was less than 75 per cent of the maximum efficient rate of domestic production for all petroleum liquids.

An important circumstance that made it possible for reserve productive capacity to be created from the new discoveries between 1924 and 1941 was the development by the industry of engineering principles that resulted in greater recovery of oil from reservoirs, the avoidance of wasteful practices, and the action of producing states in adopting and improving conservation regulations. In the absence of such action, the industry probably would have experienced a repetition of its earlier pattern in which new discoveries first resulted in a flood of oil and were soon followed by a scarcity as the rapid decline in productive capacity of the new fields made it difficult for the industry to continue satisfying increased demands. The volume of discoveries after 1926 emphasized the waste incident to unrestricted production. It became apparent that unrestricted production from all wells caused underground physical waste because of dissipation of pressure, uneven withdrawals, and other unsatisfactory production practices. To prevent such physical waste, many oil producing states developed conservation laws and regulations which included the limitation of production to maximum efficient rates or to market demand, whichever was lower. The substantial productive capacity brought into existence by competitive development was thereby utilized for the best interests of the country through state conservation regulations. The combination of private enterprise and local regulation under the police power of the states in the interest of conservation brought about the creation of the large reserve productive capacity that existed in 1940 and proved so valuable to the United States in World War II.

1942-46

The opportunity to develop additional capacity was sharply curtailed during World War II by restrictions on

TABLE 1

YEAR	CRUDE OIL PRODUCTION Thousand Barrels		Proved Crude Oil Reserves December 31 Million Barrels	Withdrawal Rate Percent of Reserves on January 1	New Discoveries And Revisions Million Barrels	Oil Wells Producing Year End	Production Per Well Barrels Daily
	Annually	Daily					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1918	355,928	975	6,200	....	....	203,375	4.8
1919	378,367	1,037	6,700	6.1	878	227,000	4.8
1920	442,929	1,210	7,200	6.6	943	251,000	5.1
1921	472,183	1,294	7,800	6.6	1,072	274,500	4.9
1922	557,531	1,528	7,600	7.1	358	284,880	5.5
1923	732,407	2,007	7,600	9.6	732	290,100	7.0
1924	713,940	1,951	7,500	9.4	614	299,100	6.6
1925	763,743	2,092	8,500	10.2	1,764	306,100	6.9
1926	770,874	2,112	8,800	9.1	1,071	318,600	6.8
1927	901,129	2,469	10,500	10.2	2,601	323,300	7.7
1928	901,474	2,463	11,000	8.6	1,401	327,800	7.6
1929	1,007,323	2,760	13,200	9.2	3,207	328,200	8.4
1930	898,011	2,460	13,600	6.8	1,298	331,070	7.5
1931	851,081	2,332	13,000	6.3	252	315,850	7.2
1932	785,159	2,145	12,300	6.0	85	321,500	6.7
1933	905,656	2,481	12,000	7.4	605	326,850	7.7
1934	908,065	2,488	12,177	7.6	1,085	333,070	7.5
1935	996,596	2,730	12,400	8.2	1,220	340,990	8.1
1936	1,099,687	3,005	13,063	8.1	1,763	349,450	8.7
1937	1,279,160	3,505	15,507	9.7	3,723	363,030	9.8
1938	1,214,355	3,327	17,348	7.8	3,055	369,640	9.1
1939	1,264,962	3,466	18,483	7.3	2,400	380,390	9.2
1940	1,353,214	3,697	19,025	7.3	1,895	389,010	9.6
1941	1,402,228	3,842	19,589	7.4	1,967	399,960	9.7
1942	1,386,645	3,799	20,083	7.1	1,880	404,840	9.4
1943	1,505,613	4,125	20,064	7.5	1,487	407,170	10.2
1944	1,677,904	4,584	20,453	8.4	2,067	412,220	11.2
1945	1,713,655	4,695	20,827	8.4	2,087	415,750	11.3
1946	1,733,939	4,751	20,874	8.3	1,781	421,460	11.3
1947	1,856,987	5,088	21,488	8.9	2,471	426,280	12.0
1948	2,016,282	5,509	23,280	9.4	3,809	435,000	12.8
1949	1,846,000*	5,058*	.....	7.9	....	.....	....

SOURCE: Columns 1, 2, 3, 5, and 6— PETROLEUM INDUSTRY RECORD, 1918-48—Oil Industry Information Committee. Column 4—Calculated—Annual production divided by reserves on January 1. Column 7—Calculated—Average daily production divided by average producing wells.

* Based on Bureau of Mines release of January 1, 1950.

the use of steel, by lack of manpower, and by price controls based on prewar levels. Consequently, the industry failed to increase materially reserves or productive capacity in the years 1940-45. In fact, the estimates of the Petroleum Administration show that maximum efficient rates of crude oil production decreased slightly in the years 1943-45. (See Chart 1, and Note 1.) At the end of 1945 proved reserves were less than 10 per cent above the level five years before, whereas production that year was 27 per cent greater than in 1940. Consequently, the rate of withdrawal from proved reserves increased from 7.3 per cent in 1940 to 8.4 per cent a year in 1944-45. (See Table 1.)

1946-49

The inordinate requirements of liquid fuels for military purposes during World War II made it necessary to restrict civilian consumption by rationing of gasoline and fuel oils. Civilian use increased so greatly following the close of the war that demand in 1946 remained at the peak wartime level of 1945, even though military consumption decreased. In 1947 demand showed an extraordinary increase of about 11 per cent over 1946 and in 1948 a further increase of about 4 per cent. Meanwhile, the development of additional oil resources was handicapped by a continuing

TABLE 2

YEAR	TOTAL WELLS DRILLED: Oil	Dry	Total	Total Footage Drilled 000 Ft.	VALUE OF PRODUCTION MILLION DOLLARS: Current Dollars	Constant Dollars	Average Price At Well $/Bbl.	Wholesale Price Index 1935–39 =100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1918	17,845	5,613	25,687	N.A.	704	432	1.98	162.9
1919	21,052	5,986	29,173	N.A.	760	442	2.01	172.0
1920	24,273	7,364	33,911	N.A.	1,361	712	3.07	191.2
1921	14,666	5,160	21,937	N.A.	815	673	1.73	121.1
1922	17,333	5,332	24,689	N.A.	895	746	1.61	120.0
1923	16,206	5,865	24,438	N.A.	978	784	1.34	124.8
1924	14,587	5,044	21,888	N.A.	1,023	841	1.43	121.7
1925	16,559	6,734	25,623	76,595	1,285	1,001	1.68	128.4
1926	19,013	7,965	29,319	82,477	1,448	1,167	1.88	124.1
1927	14,442	7,210	24,143	72,267	1,173	991	1.30	118.4
1928	12,526	7,078	22,331	74,295	1,055	879	1.17	120.0
1929	15,572	7,914	26,356	88,053	1,280	1,083	1.27	118.2
1930	11,640	6,734	21,240	68,762	1,070	998	1.19	107.2
1931	6,788	3,659	12,432	37,892	551	608	0.65	90.6
1932	10,444	3,569	15,040	47,682	680	846	0.87	80.4
1933	8,068	3,312	12,312	39,568	608	743	0.67	81.8
1934	12,520	4,309	18,197	56,141	905	974	1.00	92.9
1935	14,663	4,911	21,420	67,845	961	968	0.97	99.3
1936	17,800	5,297	25,890	80,997	1,200	1,198	1.09	100.2
1937	22,386	6,560	33,075	105,099	1,513	1,413	1.18	107.1
1938	18,598	6,141	27,493	90,585	1,373	1,408	1.13	97.5
1939	17,625	6,474	27,717	85,523	1,294	1,352	1.02	95.7
1940	19,125	6,617	30,041	96,183	1,385	1,421	1.02	97.5
1941	19,552	7,128	32,053	99,348	1,602	1,479	1.14	108.3
1942	10,492	5,504	19,824	67,903	1,643	1,340	1.19	122.6
1943	9,717	6,385	19,431	61,992	1,809	1,414	1.20	127.9
1944	13,028	7,009	25,260	84,378	2,033	1,576	1.21	129.0
1945	14,297	7,471	26,875	92,982	2,094	1,595	1.22	131.3
1946	15,851	8,047	29,225	101,125	2,443	1,626	1.41	150.2
1947	17,961	9,625	33,173	112,816	3,578	1,896	1.93	188.7
1948	22,585	12,026	39,778	134,659	5,262	2,569	2.61	204.8
1949	22,042*	14,109*	39,038*	138,003*	4,689†	2,438‡	2.54†	192.3‡

SOURCE: Columns 1, 2, 3, and 7—PETROLEUM INDUSTRY RECORD, 1918-48—Oil Industry Information Committee. Column 4—WORLD OIL, February, 1949, page 104. Column 5—Calculated—Crude Oil Production multiplied by average price at well. Column 6—Calculated—Value of production in current dollars (Col. 5) converted to constant dollars on basis of price index in Column 8. Column 8—Calculated—U. S. Bureau of Labor Statistics Index (1926 =100), converted to 1935-39 =100.

* Based on OIL and GAS JOURNAL. † Bureau of Mines release dated January 1, 1950. ‡ Estimated. N.A.—Not available.

Note 1—Estimates of available productive capacity by the Petroleum Administration for War for the years 1940-45 and by the Subcommittee on Long-Term Availibility for the year 1949 are considered to be generally comparable, although prepared by different organizations. The estimate of the Petroleum Administration for War at the end of 1945 apparently was based on a lower ratio of annual production to proved reserves at the beginning of the year than were the estimates for 1940 and 1949, as indicated by the following tabulation:

	Proved Crude Oil Reserves on Jan. 1	Estimated Crude Oil Availability		Ratio of Availability to Proved Reserves	Prod. of Nat. Gas Liquids	Est. Total Petroleum Availability
	Million Bbls.	Thousand Bbls. Daily	Million Bbls. Per Year	on Jan. 1	Thousand Bbls. Daily	
1940	18,483	4,745	1,737	9.4%	152	4,897
1945	20,453	4,555*	1,663	8.1%	302	4,857
1949	23,280	5,875	2,144	9.2%	425	6,300

*Estimate for the fourth quarter of 1945 by the Petroleum Administration.

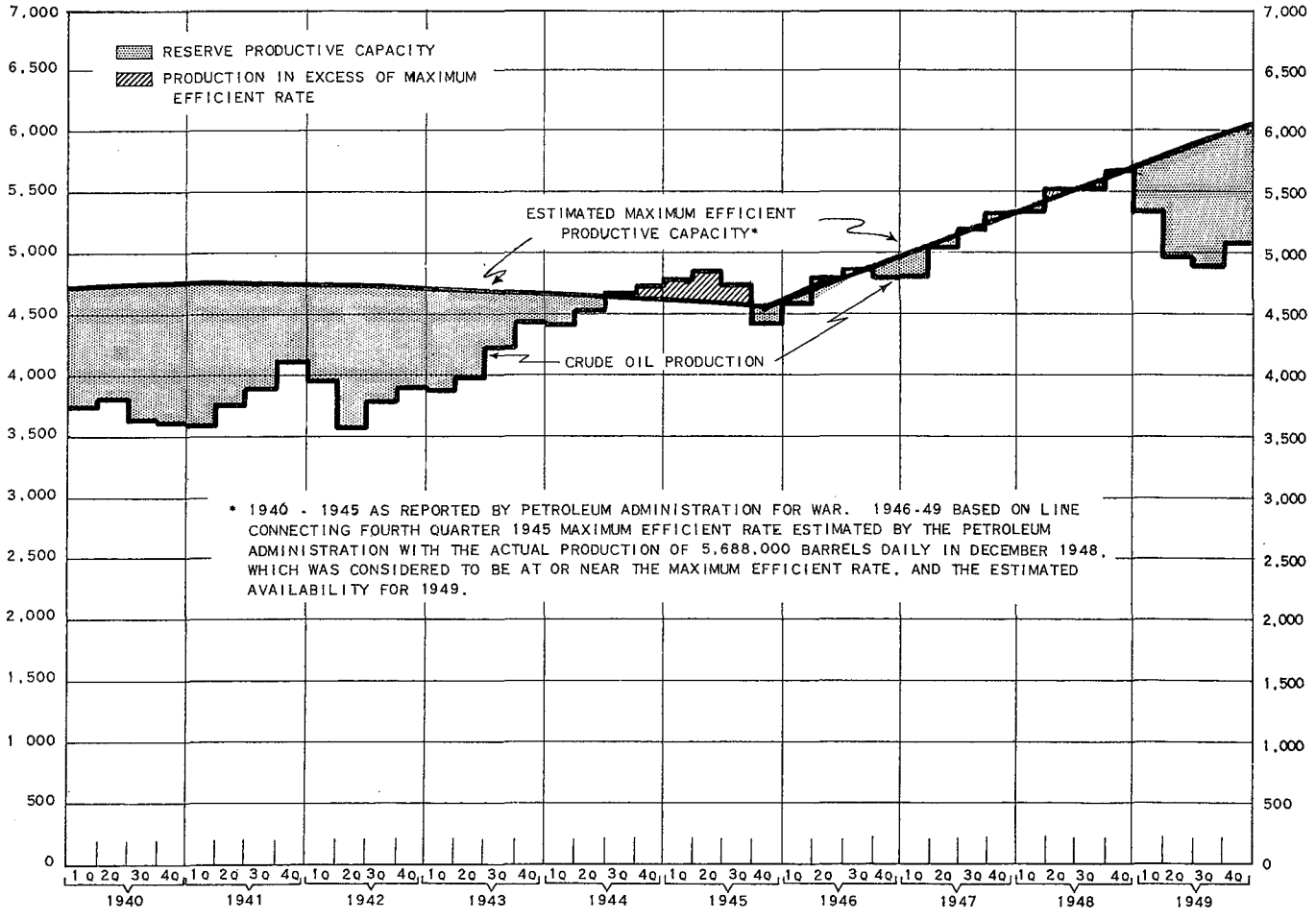
shortage of materials and by price controls that were not removed until July 1946. In spite of a rapid increase in drilling operations, there was a further rise in the rate of withdrawal from proved reserves until 1948, when production was equal to 9.4 per cent of the proved reserves at the beginning of the year. The results of the industry's vigorous development effort became apparent in 1948 and 1949, however, as proved reserves and productive capacity advanced substantially ahead of demand, resulting in the restoration of a substantial margin of productive capacity. The number of wells drilled by the industry increased to more than 33,000 in 1947 and exceeded 39,000 in 1948 and in 1949, compared with the low point during the war of 19,400 in 1943 and the previous record of 33,900 in 1920. (See Table 2, Column 3.) The rate of withdrawal from proved reserves declined to 7.9 per cent in 1949, or less than the rate prevailing in 1935-36 when substantial reserve productive capacity existed.

The oil industry has increased productive capacity by 1,600,000 barrels daily since the conclusion of the war. In November 1948 the Subcommittee on Long-Term Availability of the American Petroleum Institute estimated that the United States would be able to produce at maximum efficient rates between 6,120,000 barrels daily and 6,300,000 barrels daily of all petroleum liquids in 1949. Taking into account the extent by which drilling in 1948 and 1949 was greater than estimated by the Subcommittee on Long-Term Availability in preparing its report, this Committee has reached the conclusion, following a check of estimates in the producing districts, that a reasonable figure for the availability of all petroleum liquids is 6,300,000 barrels daily for the year 1949 (the upper range indicated for this year by the Subcommittee on Long-Term Availability) and 6,450,000 barrels daily for December 1949. The comparable figure for all petroleum, including natural gas liquids, estimated by the Petroleum Administration for War in the fourth quarter of 1945 was 4,857,000 barrels daily. The difference between these two figures of nearly 1,600,000

CHART 1

U. S. CRUDE OIL PRODUCTION AND ESTIMATED PRODUCTIVE CAPACITY

(Thousand Barrels Daily)



barrels daily indicates addition to available productive capacity at a rate of 400,000 barrels daily per year in the past four years.

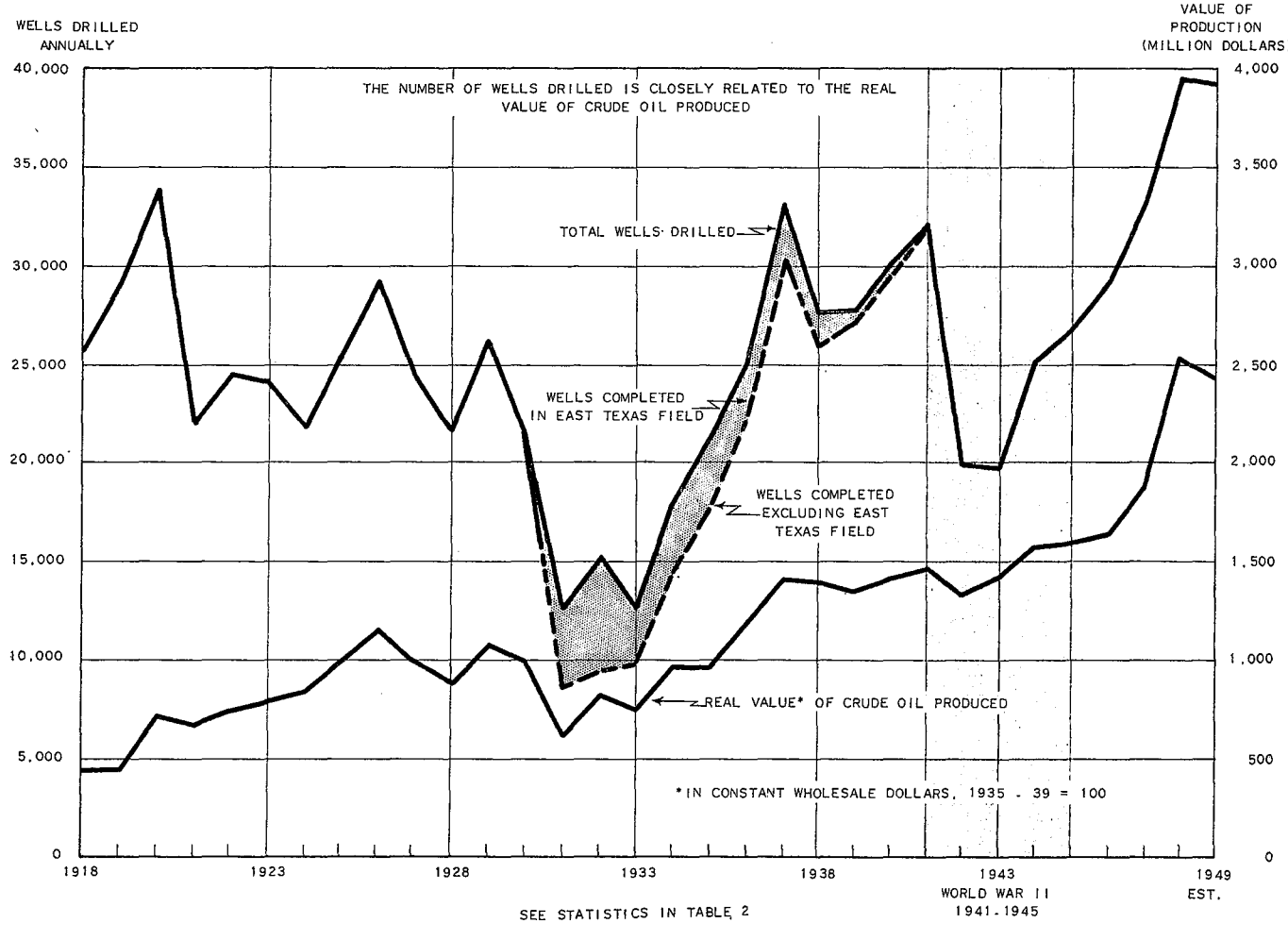
Domestic demand for petroleum liquids in 1949 of 5,750,000 barrels daily was approximately 550,000 barrels daily less than the average available producing capacity. Domestic production of all petroleum liquids in 1949 was less than domestic demand because of the excess of imports over exports. The available capacity of 6,300,000 barrels daily was approximately 15 per cent greater than the production of 5,480,000 barrels daily in 1949. By comparison with either domestic demand or production, a substantial margin of reserve capacity now exists, having been created within the past two years even though demand has continued to increase slightly. The industry was able to overcome the handicaps of the war period and regain its normal position of operating below capacity because removal of price controls in July 1946 permitted the market to reflect the necessary stimulus for the expansion of capacity.

Analysis of Factors that Have Created Reserve Capacity

The principal factors that operated to create reserve productive capacity in the past have been (1) competition in the search for oil, (2) a market reflecting changes in supply and demand, and (3) conservation practices developed by the industry and applied under state laws.

(1) *Aggressive competition* by thousands of operators under a system of private enterprise has been the major factor in discovering large quantities of oil in the United States. Under the stimulus of the profit motive, the search for oil has been very intensive. Even areas generally considered unfavorable for the discovery of oil frequently are tested, sometimes with success, by individuals or companies who refuse to accept the general view. Countless examples can be cited of fields discovered after numerous failures by different operators. Only a system of private enterprise would bring about the repeated venture of capital required to discover production under such circumstances.

CHART 2
WELLS DRILLED AND VALUE OF CRUDE OIL PRODUCTION



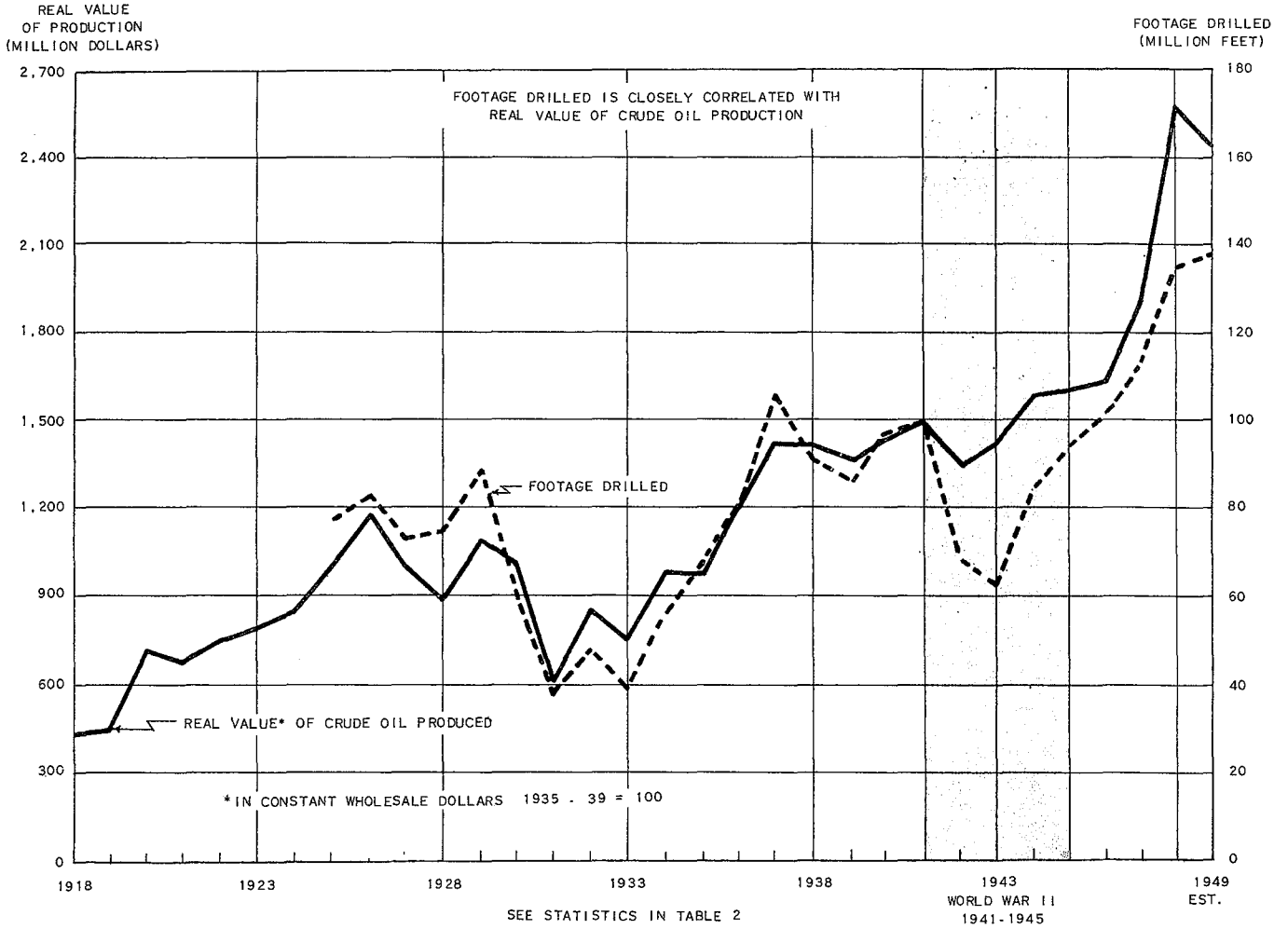
SEE STATISTICS IN TABLE 2

Unregulated competitive enterprise in the development of oil, where land ownerships are divided between a number of operators, is subject to the limitation that it tends to bring about unduly rapid withdrawal as each operator seeks to produce the maximum amount through his wells. To prevent the waste that results from such practice, the principal producing states have adopted laws regulating drilling and production of wells. It is private enterprise, however, which has created the potential capacity and developed and applied the sound engineering practices to conserve such capacity with the assistance of the states through the exercise of their police powers.

(2) *A market reflecting changes in supply and demand* has operated to create reserve capacity through its influence on exploration and the investment of additional capital in oil properties and in wells. Any tendency for supply and demand to get out of balance due to different rates of growth soon reflects itself in price, and the change in price operates automatically to help restore a proper balance. Volume and price determine the value received by the industry for its production, and it is that value which regulates the rate of development of new oil resources. When value declines due to the need for less oil or a lower price, the footage and number of wells drilled declines; when the value of oil production increases due to the need for more oil or an increase in price, the footage and number of wells drilled increases. This close correlation is shown in Charts 2 and 3 and it is also evident from the figures in Table 2. (See Columns 3, 4, and 6.)

A substantial amount of drilling is required on the part of the petroleum industry merely to replace the annual production and thereby maintain productive capacity. In the years 1940-45, for example, the industry drilled 153,000 wells, of which 86,200 were oil wells (See Table 2, Columns 1 and 3), but productive capacity did not show much change. To meet the expanding demand which has

CHART 3
FOOTAGE DRILLED AND VALUE OF CRUDE OIL PRODUCTION



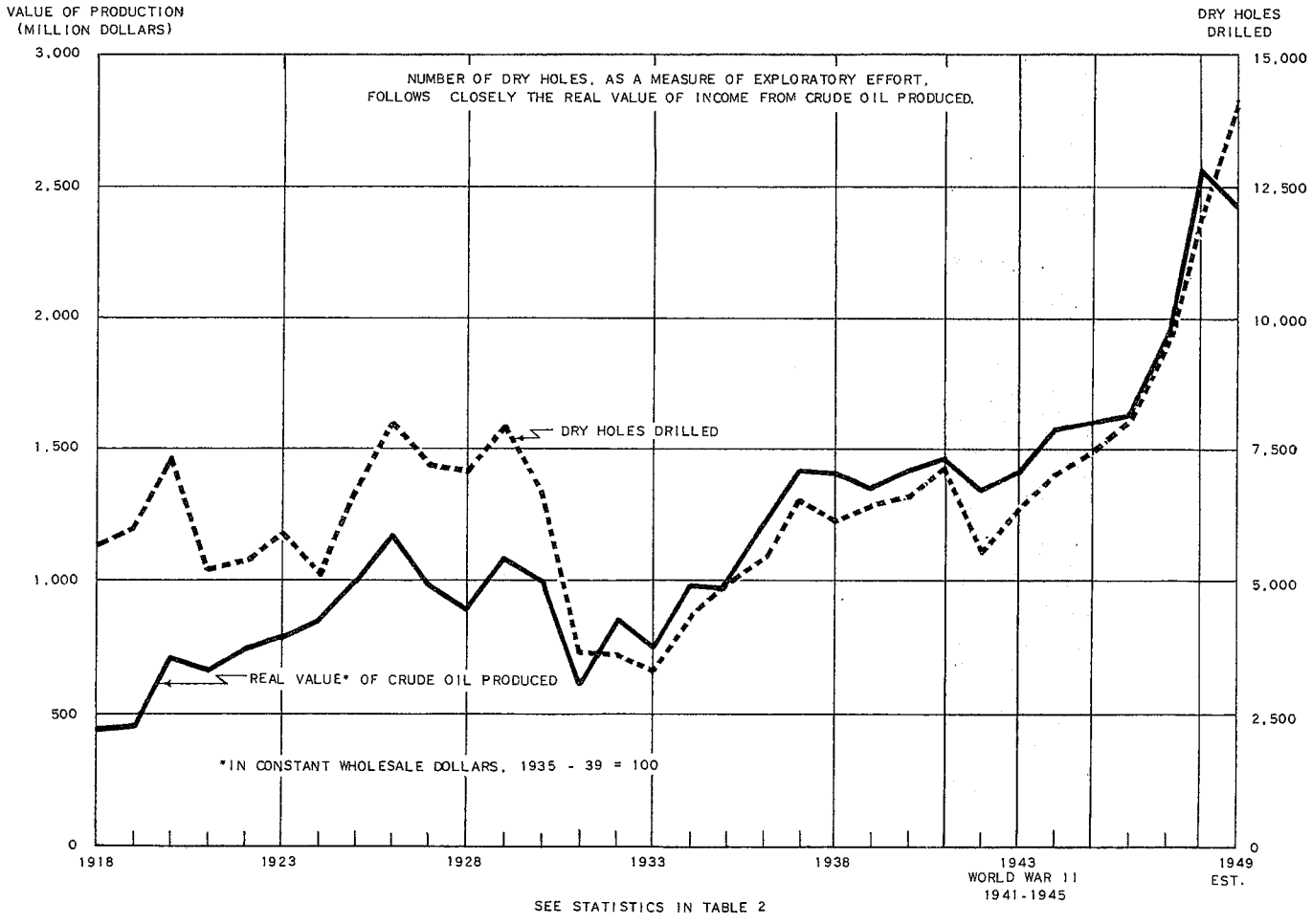
characterized the operations of the petroleum industry, it has been necessary to do more than maintain capacity. Additions to productive capacity depend on the extent to which the number of wells drilled and reserves developed exceed the rate required to maintain capacity. The record drilling operations during the past thirty years have occurred when the value of oil production was rising due to the combination of increased volume and the influence of greater demand on price. This relationship is particularly evident for 1933-37 and for 1947-49, as disclosed by Charts 2 and 3.

The close correlation between the value of production and drilling naturally affects the rate of discovery of oil and the development of productive capacity. Chart 4 shows a close correlation between the number of dry holes drilled, which is a significant measure of exploratory effort, and the value of production. Chart 5 shows that discoveries and reserves follow the trend of well completions, which in turn follows the value of oil production. The inescapable conclusion from these relationships is that an increase in value of production, whether due to additional volume or improved prices, stimulates drilling and the discovery and development of oil resources. On the other hand, a decrease in the value of production operates to retard drilling and the discovery and development of new oil.

A market reflecting changes in supply and demand is of great importance to the creation of reserve productive capacity in view of the close relation which exists between the value of production and the development of new productive capacity. In oil production, as in industrial operations generally, operations are more satisfactory at a level moderately below absolute capacity, because of the greater flexibility that exists with a margin of reserve capacity. Consequently, the normal tendency has been for the oil industry to develop a margin of reserve productive capacity whenever its operations were free to respond to changing conditions of demand and supply.

(3) *Conservation practices* developed by the in-

CHART 4
DRY HOLES DRILLED AND VALUE OF CRUDE OIL PRODUCTION

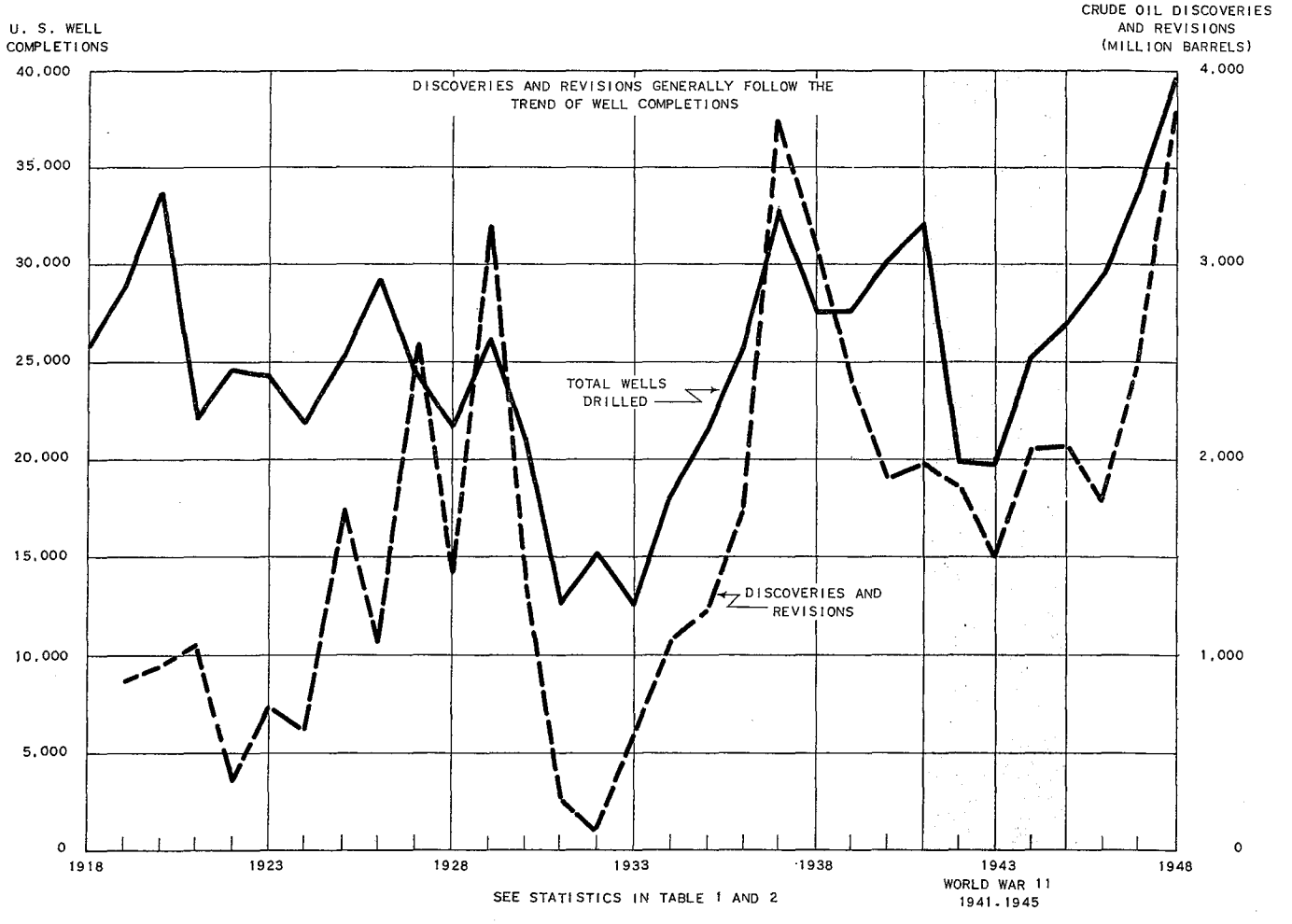


SEE STATISTICS IN TABLE 2

dustry have served to increase substantially the amount of oil recovered from the fields found. The application of these practices has been greatly aided by state conservation laws. These laws were adopted to prevent waste and protect correlative rights of competing operators in the same field. In a number of the principal producing states, such as Texas, Louisiana, Oklahoma, and New Mexico, the laws authorize the conservation agency to restrict production to market demand, if demand happens to be less than the maximum efficient rate of production. Such action has been found necessary in actual practice to prevent physical waste. Experience demonstrates that production in excess of market demand often leads to uneven and inequitable withdrawals by different operators in the same field, resulting in conditions that bring about physical waste in the reservoir. Production greater than market demand leads likewise to excessive storage with consequent losses from evaporation, fire, and other hazards. Furthermore, failure to consider market demand in regulating production would give the new, flush fields with low costs so great an advantage over old fields as to cause premature abandonment of wells and loss of reserves that would otherwise be recovered.

Regulation of production to market demand does not determine the level of prices, although it does influence price by tending to decrease the frequency and extent of fluctuations. Actually, under its operation in the past, a lower average level of prices has obtained than prevailed prior to the application of market demand as a factor in regulating production. The average price for the 8 billion barrels of oil produced in the years 1918-29 was $1.60 a barrel. (Table 2.) The average price of the same quantity of oil produced in the years 1934-40, after the effective application of conservation laws, was $1.06 a barrel. Even in the recent period 1945-49, the average price for the 9 billion barrels of oil produced was $1.97, or 23 per cent above the average in 1918-29, whereas wholesale com-

CHART 5
WELLS DRILLED AND CRUDE OIL DISCOVERIES AND REVISIONS



modity prices generally in 1945-49 were about 28 per cent higher than in 1918-29.

Reserve Capacity for World War II

A reserve productive capacity of more than 1,000,000 barrels daily existed at the beginning of World War II because of the favorable factors discussed in the preceding section. Reserve productive capacity would have been smaller but for the provision in some state conservation laws authorizing regulation of production to market demand to prevent waste. Such capacity exists only when some fields are producing less than their maximum efficient rates due to lack of market outlets, and the principal reserve capacity was developed in states that did have regulation to market demand.

The greatest contribution to additional production in World War II was made by Texas, which was able to increase its crude oil output from 1,385,000 barrels daily in 1941 to a wartime record of 2,165,000 barrels daily in the second quarter of 1945 because it had developed large reserve capacity. The increase in the state's production of 780,000 barrels daily during this time represented three fourths of the total increase of a million barrels daily in United States' production.

In sharp contrast to the increase in Texas during World War II was the decline in production in Illinois from an average of 363,000 barrels daily in 1941 to 207,000 barrels daily in the second quarter of 1945. The rapid decline in production in Illinois occurred because production exceeded both maximum efficient rates and market demand, as indicated by additions to stocks of crude oil. The new reserves found and developed in Illinois in 1938-40 were produced so rapidly that the maximum rate of production was passed in the second quarter of 1940 when the average was 462,000 barrels daily. By the second quarter of 1943 production in Illinois was down to 225,000 barrels daily, less than half of what it had been three years earlier, although the requirements for oil had increased materially during that time.

Reserve producing capacity was utilized during World War II to supply military demand and essential civilian requirements. The increase in requirements forced production up to the limit of maximum efficient rates by the end of 1944. Normally, the increase in demand would have stimulated additional development through the influence of volume and price on value. Wartime restrictions on prices and drilling made it impossible for the industry to carry out the development which would have occurred in ordinary circumstances in response to the increase in demand. Consequently, production was at maximum efficient rates before the end of the war. As soon as controls were removed on drilling and the use of materials, the industry began a rapid expansion in its exploration and drilling efforts, which was accelerated when price again was allowed to reflect the interplay of supply and demand. The results of these intensive efforts to develop new reserves were reflected in the rapid increase of maximum efficient rates of production, even though the shortage of steel acted as a limiting factor on drilling. Once again it was demonstrated that the operation of price in reflecting supply and demand, and the application of sound conservation practices, serve to create a margin of reserve productive capacity that is available for any contingency.

Reserve Productive Capacity for the Future

The assignment to this Committee involves consideration of the creation of reserve petroleum productive capacity for the future, which means analysis of the balance between the supply and demand that will probably develop. It is extremely difficult to anticipate supply and demand for one form of energy, oil, which is in keen competition with such other important resources as coal and natural gas. The Committee wishes to point out that crude oil supply and demand are inseparably related through the operation of price. The principal concern about reserve producing capacity doubtless arises from the belief of some people that the domestic industry cannot find oil fast enough to continue meeting further regular increases in demand. Regardless of the rate of discovery, however, price will *tend* to balance petroleum supply and demand and still leave some margin of spare capacity. In case of a decline in the rate of discovery, however, the question may be raised whether the reserve capacity will be "substantial" in the event of an emergency. The answer to this inquiry depends on the outlook for future discoveries and the magnitude of a "substantial" reserve capacity.

The fears that the United States will run out of oil are based in considerable part on the premise that a fixed quantity of oil will be found and that the amount remaining to be found is automatically reduced with each new discovery. It may be taken for granted that there is a fixed quantity of oil resources underlying the area of the United States, including the continental shelf, but the amount of such resources actually to be discovered will depend upon technology and economic incentives. Furthermore, each new discovery tends to provide additional information suggesting possibilities for further discoveries. The proportion of land producing oil to the potentially oil productive areas in the United States is relatively small and there is no question that *large additional discoveries*

remain to be made through further exploration. Even in areas already intensively explored in the past, discoveries are being made from time to time as a result of additional subsurface information, improved finding methods, and deeper drilling made technically and economically feasible by improved equipment. Technology has proved to be so effective in offsetting the tendency toward diminishing returns in the search for oil so far as to provide a basis for reasonable optimism about the outlook for future discoveries. The evidence of recent years suggests that under the proper economic incentives oil can continue to be discovered at a rapid rate in the United States. The rate of discovery and development is more likely to be affected adversely by interference with economic incentives than by the natural limitations on the existence of petroleum.

The productive capacity of the domestic oil industry can continue to increase under favorable conditions. A careful study of this subject for the period 1949-53 was made by the Subcommittee on Long-Term Availability of Petroleum for the American Petroleum Institute. A comparison of that Committee's estimate of the availability of all liquid hydrocarbons with the actual production in 1948 is shown below:

	Probable Range		
	Lower	Upper	Average
	(Barrels Daily)	(Barrels Daily)	(Barrels Daily)
1948 Production	.....	.....	5,907,000
1949	6,120,000	6,300,000	6,210,000*
1950	6,310,000	6,630,000	6,470,000
1951	6,460,000	6,920,000	6,690,000
1952	6,560,000	7,140,000	6,850,000
1953	6,600,000	7,320,000	6,960,000

*Due to drilling in excess of that anticipated for 1948-49, it appears that the availability averaged 6,300,000 barrels daily for the year 1949 and reached a level of 6,450,000 barrels daily in December 1949.

According to this study, the average estimate of availability for 1953 is more than 1,050,000 barrels daily in excess of the production in 1948. Developments of the past year show that the estimates are reasonable and suggest that the upper range can be attained under favorable economic conditions. Thus, depending on the rate of drilling, the availability in 1953 may be 7,320,000 barrels daily, which would mean a gain of 460,000 barrels daily each year over the production of 5,480,000 barrels daily of all petroleum liquids in 1949.

The margin of reserve petroleum productive capacity will depend not only on the rate of change in supply, but also on the level of demand. Over the period 1920-49 the domestic demand for petroleum in the United States increased at a cumulative rate of about 5 per cent a year. This rate of increase brought about a vast expansion in demand for liquid petroleum. Demand has now reached such volume that it is reasonable to expect a slower rate of growth for the future, probably at a rate not exceeding 3 per cent annually over a period of years, especially in view of increasing competition from natural gas.

The demand for natural gas has expanded at a more rapid rate than that for oil during the last ten years. The marketed production of natural gas in 1949 probably was about 5.7 trillion cubic feet compared with 2.8 trillion cubic feet in 1941. The increase in use of gas of 2.9 trillion cubic feet in a period of eight years represents a heat value equivalent to the use of 1,320,000 barrels daily of petroleum. Several large new gas lines are under construction and others are being planned, with the result that natural gas will probably supply markets that might otherwise have used oil, thereby slowing down the rate of growth in demand for petroleum. A specific example of this competition is evident in the use of oil and gas by utilities. In 1948 utilities generating electric power used 42,600,000 barrels of fuel oils, or 6 per cent less than their consumption of 45,300,000 barrels of fuel oils in 1947. Their use of natural gas, on the other hand, increased from 373 billion cubic feet in 1947 to 478 billion cubic fet in 1948, a gain of 28 per cent. In terms of heat value, the increase in the use of gas amounted to 18 million barrels of petroleum.

The relation between available domestic producing capacity and domestic demand will also be influenced by exports and imports. For a period of 25 years through 1947 the United States was a net exporter of oil, but in 1948 imports exceeded exports by 145,000 barrels daily and in 1949 the difference will be about 310,000 barrels daily. This change has occurred because exports are declining and imports are increasing. It remains to be seen how this change will affect domestic development of oil resources, but discussion of that question is considered beyond the scope of this Committee's assignment.

Reserve petroleum productive capacity in the United States, without taking into account imports or exports, is estimated by this Committee to have been about 550,000 barrels daily average during 1949 and 700,000 barrels daily at the end of the year (the difference between the available daily capacity of 6,300,000 barrels for the year and 6,450,000 barrels in December and the average annual domestic demand of about 5,750,000 barrels daily). If the excess of imports over exports for the year is taken into account, reserve capacity becomes 1,000,000 barrels daily at the end of the year (the difference between daily availability and production of all petroleum liquids in December). These calculations demonstrate that existing reserve capacity is substantial for a national emergency. It is probable that reserve productive capacity will remain substantial over the next few years. An increase of 2.5 per cent a year in demand between 1949 and 1953 would result in domestic

requirements in 1953 of about 6,350,000 barrels daily, or about 1,000,000 barrels daily below the availability of 7,320,000 barrels daily which probably will be attained under favorable circumstances. It appears, therefore, that a substantial reserve productive capacity, of the order of magnitude of 1,000,000 barrels daily, probably will prevail in the period 1950-53 in the absence of any new developments tending to upset the present outlook for supply and demand.

Synthetic Fuels

A long-range consideration of domestic oil resources must include the possibilities of liquid fuel production from natural gas, coal, and oil shale. Recent developments in mining, processing, and refining techniques assure that liquid fuels in substantial quantity and of a quality equal to those produced from natural crude oil can be made available from these sources, when and if warranted by the prices of products from crude oil, or if required in a national emergency. Experimental work by private industry and the U. S. Bureau of Mines on the manufacture of synthetic fuels has been valuable in proving the engineering practicability of such process, but in view of the foreseeable substantial reserve petroleum productive capacity, there appears to be no need for commercial scale production of synthetic liquid fuels from coal or shale in the next few years.

It would be of small value to attempt to estimate potential production from such sources by numbers, but it may be safely said that from either coal or shale the possible productive reserves are at least of the order of 100 billion barrels of usable liquid products.

The process of converting natural gas to liquid products has been demonstrated in commercial-sized plants which can be built and operated when required. The potential reserve from this source depends on the price and availability of natural gas and of the liquid products that can be made from it, and is not subject to estimates with any meaning.

Other Measures Useful in Case of Future Emergency

Reserve productive capacity of crude oil will be a most valuable asset in case of a national emergency, but there are also other measures that may help balance supply and demand in such a situation. The most important favorable factor in this connection is the possibility of rationing domestic consumption. During World War II, civilian gasoline use was reduced by as much as 30 per cent, the use of residual fuel oil was reduced about 170,000 barrels daily by conversion to coal, and some saving was realized by rationing heating oil for home use. Application of these measures to present consumption should make available 1,000,000 barrels daily of oil for emergency use. In case of serious need, such action taken early in an emergency would save substantial quantities for later use, to the extent that available storage capacity permits.

In addition to those already considered, measures which might help balance supply and demand in case of an emergency are the allocation of materials and manpower for continued development of petroleum resources, the encouragement of secondary recovery, and the utilization of production from Canada and Latin America. During World War II the development of oil resources was seriously retarded by a lack of steel and manpower. If the need for oil is in excess of the available capacity, higher priority could be given to petroleum operations for steel and more liberal exemptions could be granted to scientific, technical, and operating personnel. Such procedure would help maintain or increase productive capacity. Similarly, the encouragement of secondary recovery might add to the amount of oil which could be produced in an emergency through application of projects which are too expensive to undertake in normal times. Supplies may also be available from Canada and Mexico, and even from Venezuela and other South American countries provided tanker movements can be protected adequately.

Other Factors Influencing Reserve Capacity

In addition to the factors described above, other factors that will promote or retard development of new resources have a bearing on reserve productive capacity. Continuation of reasonable tax provisions designed to take into consideration the unusual risks and peculiar circumstances of the petroleum industry will affect development of additional productive capacity. Any change which would increase tax burdens on the production of petroleum above the present level would automatically reduce the incentive for development and make it that much harder to create reserve productive capacity. The provisions in the federal income tax laws allowing for percentage depletion and the charge of intangible development costs as expense have been worked out by Congress over a period of years as equitable and economical means of providing the necessary incentive for petroleum development that is indispensable to national welfare and security. Disturbance of such tax provisions would be a serious blow to the progress now being made in creating reserve productive capacity.

The policy evolved for the development and opera-

tion of the continental shelf will influence reserve producing capacity. The decision of the Supreme Court relating to the California offshore lands has created a state of uncertainty regarding the development of the entire continental shelf. The Federal Government has filed suits seeking to assert title over the continental shelf off the coasts of Texas and Louisiana. The area of the shelf is large, and it could become a substantial source of petroleum supply for the future. Regardless of the decision on final ownership or dominion as between the states and the Federal Government, conditions favorable to exploration and development of the continental shelf are important to the development of the potential capacity of the continental shelf. As to that portion which may be administered by the states, reasonably satisfactory state leasing laws are in effect and operative. As to that portion which under judicial decision or Congressional legislation may be committed to Federal administration, a sound leasing policy that will encourage development will also help create reserve productive capacity. The risks, hazards, and costs of exploring, developing, and producing this area are very great. In the opinion of this Committee, proper encouragement of development of that part of the continental shelf under Federal jurisdiction would involve Congressional legislation (1) recognizing and establishing the rights and equities of lessees from the states substantially in accord with their existing leases; and (2) providing for Federal leases upon fixed terms with management and control in the hands of the lessees and without the retention of power in the government to change the terms of leases or enlarge the obligations of the lessees after the issuance of leases. It is also important that the conservation laws of the states be extended to the outer limits of the adjacent continental shelf. These policies will contribute to the establishment and maintenance of reserve producing capacity.

The nation's interest in promoting the development of petroleum resources and creating reserve productive capacity doubtless will be taken into account in national policy on all matters that would influence such development favorably or unfavorably. Any interference with price, disturbing its reflection of supply and demand conditions, would be a major handicap to maintaining available productive capacity. It is recognized that some influence is exerted by government action on demand and supply, as in the case of taxes on gasoline and conservation regulation of production to maximum efficient rates or to market demand. Such regulations, however, do not fix prices nor prevent the forces of supply and demand and competition between individual units in the industry from determining prices. Artificial regulations on price inevitably tend to disrupt the normal adjustment of supply and demand as they did during World War II.

Other policies that would retard development of reserve capacity include any direct participation by the government in petroleum operations, imports in excess of economic needs, and withholding of public lands from development. The direct participation of the government in any phase of petroleum operations or through the construction of synthetic fuel plants in competition with petroleum refining would constitute a major threat to private development. An agency supported by government funds and in a position to ignore costs would place private industry at such great disadvantage as to discourage investment in petroleum.

The purchase by the government of proved domestic reserves to be withheld from market and the accumulation of large stocks in storage tanks also would be detrimental to the policy of creating reserve productive capacity. The mere existence of such reserves or stocks in the hands of government would constitute a constant threat to normal operations of the industry. If the government engaged in such practice, it would be subjected inevitably to great pressure to purchase oil in periods of abundant supply or sell it in periods of tight supply. Such possibility would in itself interfere with the price adjustments that are part of the process of creating reserve productive capacity.

An important problem which must be faced in connection with creation of reserve productive capacity is the role of imports in meeting domestic demands. The interest of government in reserve capacity arises from the fact that oil is of such great importance to national security that the country cannot become unduly dependent on foreign resources which may be unavailable in case of an emergency, The National Petroleum Council has stated the views of the industry with reference to imports and the maintenance of a healthy domestic petroleum industry in *A National Oil Policy for the United States* approved by the Council on January 13, 1949. If that policy is followed it will lead to the development of reserve producing capacity in the United States. This Committee has not undertaken any detailed consideration of the effect of import policies, as such assignment was given to the Committee on Imports appointed by the National Petroleum Council at the same time this Committee was appointed.

The interest of the government in developing reserve productive capacity necessarily means that private exploration and development must be encouraged. A corollary of that proposition is that the government can stimulate such activities on public lands by making them freely available for lease.

Conclusion

Twice within the past quarter century the American petroleum industry, by creating a substantial margin of reserve productive capacity, has dispelled fears of a shortage that would endanger national security. During the 1930's it created a reserve capacity of more than 1,000,000 barrels daily which proved invaluable in World War II. Since the end of the war it has again expanded capacity rapidly and built up an available reserve of about 700,000 barels daily. In spite of the production of about 31 billion barrels of oil in the years 1925-49 and the great increase in demand, the United States now has much larger proved reserves than in 1925 and enjoys a comfortable relation between reserves and production.

The conclusions arrived at by the Committee as a result of its study of the problem of providing a substantial reserve capacity to be available in the event of an emergency may be summarized as follows:

1. A substantial reserve crude oil productive capacity existed in 1949, amounting to 550,000 barrels daily average for the year and 700,000 barrels daily in December. If the excess of imports over exports for the year is taken into account, reserve capacity at the end of 1949 becomes 1,000,000 barrels daily. Reserve productive capacity of the order of magnitude of 1,000,000 barrels daily probably will prevail in the period 1950-53 in the absence of any new developments tending to upset the present outlook for supply and demand.

2. In case of an emergency, rationing should make available 1,000,000 barrels daily of oil for emergency use, which would be as valuable for national security as reserve productive capacity of that amount.

3. In view of the foreseeable substantial reserve crude oil productive capacity, there appears to be no need for commercial scale production of liquid fuels from coal or shale in the next few years. However, substantial quantities of synthetic liquid fuels can be made available from natural gas, coal, and oil shale, when and if warranted by the prices of products from crude oil, or if required in a national emergency, given sufficient time and an adequate supply of materials.

4. The principal factors that operated to create reserve productive capacity in the past have been (1) aggressive competition in the search for oil, (2) a market reflecting changes in supply and demand, and (3) conservation practices developed by the industry and applied under state laws.

5. The changing value of production has stimulated adequate development to maintain reserve productive capacity in the face of greatly expanded demands and increased costs.

6. The development of reserve capacity calls for continued application, improvement, and extension of state conservation laws and the encouragement of private enterprise in crude oil producing activities.

7. Policies which would hamper progress in maintaining substantial reserve capacity include any increased tax burdens on the production of oil, imports in excess of economic needs, the withholding of public lands from development, direct participation by the government in petroleum operations, and any government interference with price.

8. Sound leasing policies are necessary to the development of the potential capacity of the continental shelf and will have an important bearing on the establishment of reserve producing capacity.

9. Artificial controls intended to bring about the "planned" creation of reserve capacity would destroy flexibility and hamper the very adjustments that normally tend to create reserve capacity.

10. Creation of substantial reserve capacity in oil production is best achieved when the industry is allowed to continue functioning as it has in the past with a minimum of controls, other than state regulation for conservation purposes, and is encouraged by maintenance of a favorable economic environment.

This Committee was requested not to make plans or programs for providing a substantial domestic reserve producing capacity to be available in the event of an emergency. It wishes to express the conclusion, based on its studies, that no plans or programs are necessary or would help to achieve the desired result. The normal competitive operations of the industry, in a favorable economic climate, unhampered by new regulations, will tend to bring about larger productive capacity that will provide a satisfactory margin of reserve productive capacity.

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