ELECTRIC POWER--AN ESSENTIAL COMPONENT OF NATIONAL SECURITY

4 March 1954

1547

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Washington, D. C.

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Mr. Philip Sporn, President of the American Gas and Electric Company and its subsidiaries, was born in Austria in 1896. He was graduated from Columbia University, School of Engineering, in 1917 and received the M. S. degree from Columbia in 1918. Stevens Institute awarded him an honorary degree of Doctor of Engineering in 1947 and he received the degree of Doctor Honoris Causa at the University of Grenoble (France) in 1950. Mr. Sporn is a scientist, engineer, and administrator, who has devoted his entire life to the advancement of the electric power industry and is noted for pioneering work in this field. He is responsible for the design, construction, and operation of the Twin Branch Power Station which operates at a boiler pressure of 2,300 pounds per square inch, the highest pressure regularly used in an operating station in the United States. He had many responsibilities in developing the techniques of operating all the power systems of the eastern United States as one unit during World War II. This vast network was governed by the Philo station of the Ohio Power Company which was designed and constructed under Mr. Sporn's direction. He is the moving spirit in the development of the "heat pump," which may completely revolutionize all present concepts of residence and commercial heating. He has been the directing head of many experiments now being conducted in the art of electric transmission. He has written many papers for technical and scientific societies, and has received many citations for his contribution to the industry. Most of his professional life has been spent with the American Gas and Electric Company and its subsidiaries, where he has risen from an engineer through all grades to his present position of president.

ELECTRIC POWER--AN ESSENTIAL COMPONENT OF NATIONAL SECURITY

4 March 1954

COLONEL NORMAN: General Greeley, gentlemen: For the last couple of weeks we have been considering some of the supporting, but nevertheless very vital factors, to our national economy. This morning we take up another one of those factors--I refer to power.

Mr. Sporn, President of the American Gas and Electric Company, has literally grown up with the power industry. He can truly be said to be a scientist, an engineer, and an administrator in this field. We are very fortunate to have someone who has such a comprehensive background and knowledge and experience in this field talk with us on "Electric Power--An Essential Component of National Security."

Mr. Sporn, it really is a pleasure and an honor to welcome you back to the Industrial College, I think for at least the fifth consecutive year, or maybe more. Mr. Sporn.

MR. SPORN: General Greeley, Colonel Norman, gentlemen: I am very happy to be here again and to have the privilege of addressing a group that is going about this very serious business of learning in a period of 10 months the essentials of our industrial complex, fundamental, I think, in our system of national security.

The subject of power is a very ambitious subject, particularly if it is to be covered in the short time that we have available this morning. For a number of years, in my talks before groups here, I have, as a matter of necessity, used a series of charts and then talked more or less extemporaneously around those charts. It seemed to work out quite well on previous occasions and so this morning I am using the same mechanics for the delivery of my talk.

My talk is going to be divided into four parts: The first part is the electric power industry as it is, and as it has been; second, why electric power has to expand; the third, what is ahead for and in electric power; and the fourth, some significance of these developments for national security.

I do not have to tell you gentlemen that ours is a power-operated economy. Our great industrial machine is a power-driven machine.

Our great productivity stems from and is dependent upon heavy utilization of electric power, supplied more and more--and that becomes more true with each year--by our utility supply systems.

Now, on the average--and that does mean specifically that this does not apply in special energy-using industries such as aluminum reduction, or titanium reduction, or electric steel, or the manufacture of chromium, or sodium--power represents only about seven-tenths of 1 percent of the cost of an industrial operation. But I think it is very important to remember that, small as that percentage is, it is a critical percentage. If it is absent, you have absolutely no production, and the other 99.3 percent is of no avail.

Incidentally, it is very interesting that seven-tenths of 1 percent is the percentage of U-235 in natural uranium. So maybe you can see that power is what causes things to move in our industrial machine just as U-235 does the real moving in uranium.

The Electric Power Industry as Is--as Has Been

Chart 1, page 3.--All I want to bring out in this chart is, first, you can see the very close relationship between power production and gross national product. The two curves are very closely linked. They have exactly the same shape, except for one thing--the power curve is moving much faster than the gross national product curve. It is rising at a much faster rate. Even during the industrial depression, which we had in the thirties, you will notice power returned to normal much faster, many years before gross national product. I think that is a fundamental relationship because the more you go into the matter, the more you will find that power is one of the necessary tools which helps us to move off the dead center that is characteristic of an industrial depression.

Table 1, page 4.--In this table I have shown the latest figures on production of electric energy, total and per capita, in the various countries of the world. Again the significant thing here is, that we in the United States are in the forefront of all the energy-producing countries of the world.

You will notice that in 1952 there were produced some 463 billion kilowatt-hours in the United States, a figure that literally puts into almost insignificance all the other figures, and we are very close to being the highest on a per capita basis. There are only two countries--and there are special situations in each case--Canada and Norway, that have higher per capita figures.

CHART 1

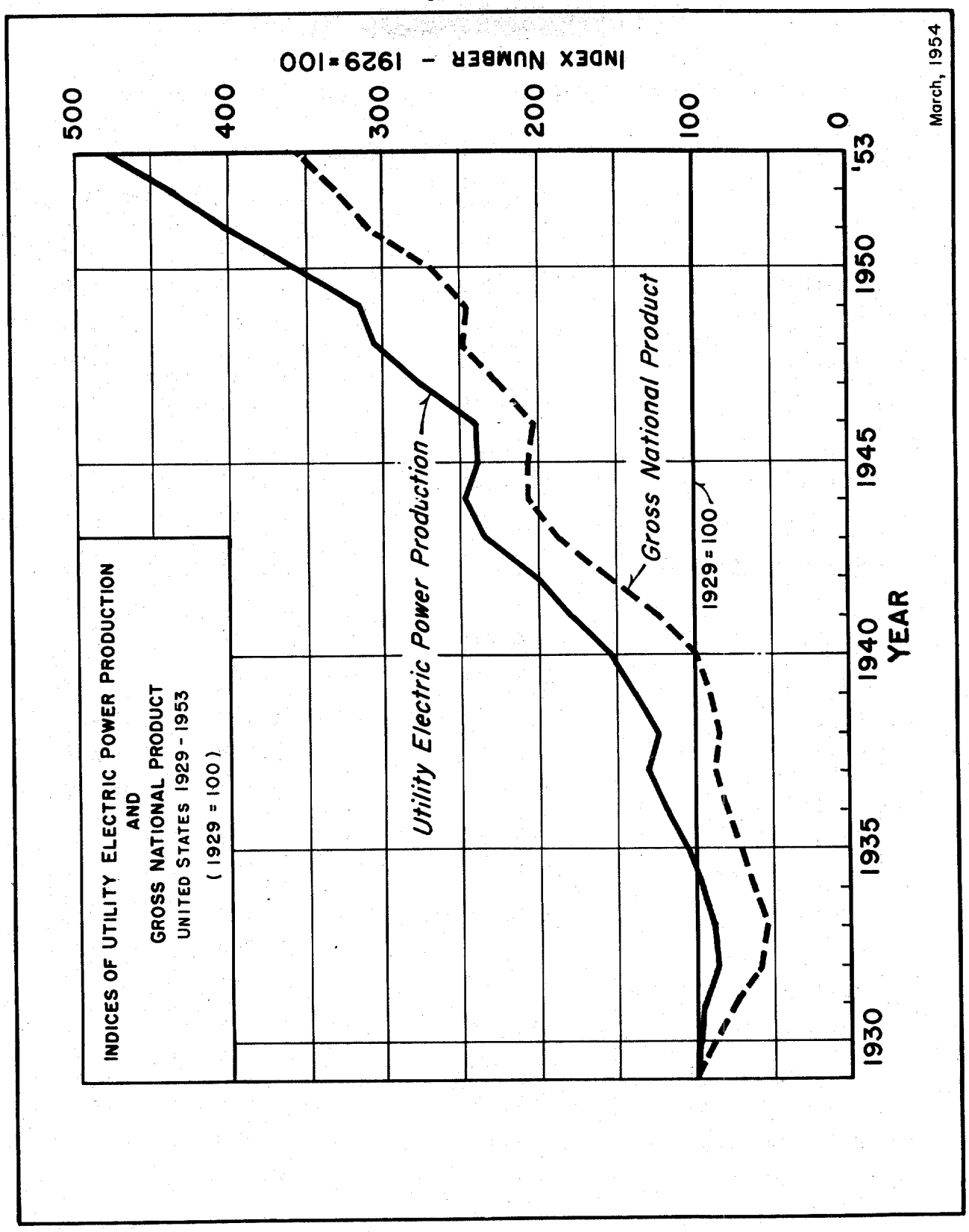
INDICES OF UTILITY ELECTRIC POWER PRODUCTION
AND
GROSS NATIONAL PRODUCT
UNITED STATES 1929 - 1953
(1929 = 100)
INDEX NUMBER - 1929=100
500
400
300
200
100
0
Utility Electric Power Production
Gross National Product
1929=100
1930
1935
1940
1945
1950
'53
YEAR
March, 1954

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TABLE I

PRODUCTION OF ELECTRIC ENERGY PER CAPITA IN VARIOUS COUNTRIES OF THE WORLD 1952

(Countries of 40,000,000 or more population underscored)

Country	Population (000's)	Kwh Produced (000,000's)	Kwh/Capita
Argentina	18,056	4,701	260
Austria	6,949	8,135	1,170
Belgium	8,705	9,468	1,088
Brazil	54,477	7,484[1]	138
Canada	14,430	68,500	4,750
Chile	5,932	1,870	315
China[2]	463,493	1,879	4
France	42,600	40,152	945
Western Germany	48,478	56,208	1,160
Israel	1,430	669	467
Italy	46,865	31,138	666
India	367,000	6,492	18
Japan	85,500	43,812	512
Mexico	26,922	5,331	206
Norway	3,327	18,396	5,530
Pakistan	75,842[3]	300	4
Philippines	20,631	559	27
Spain	28,306	10,000	354
Sweden	7,126	20,700	2,905
Switzerland	4,815	11,700	2,430
Turkey	21,983	1,065	49
United Kingdom	50,429	72,800	1,441
United States	156,981	462,589	2,950
U.S.S.R. (Est.)	193,000[4]	117,000	606

Note: [1] 1950
[2] 1948
[3] 1951
[4] 1946

Sources: EEI
Statistical office of the United Nations

You might also just take a look at the best figure we have--I think it is a fairly good estimate--of Soviet Russia for the year 1952 of 606 kilowatt-hours per capita, compared with our figure of 2,950 kilowatt-hours.

Table 2, page 6.--I want to make this observation, that in spite of our almost dominating position, accounting for over 40 percent of the power produced in the world as far back as 1920, in the year 1952 we still held that same position. I think all of you know that in the intervening 32 years the world as a whole started to electrify: And although the rest of the world had a considerable amount of catching up to do, we held our position of well over 40 percent; that is, we accounted for over 40 percent of all the electric energy produced in the world.

There are two other things I want to show in this table. One is that while Soviet Russia had only four-tenths of 1 percent of the world's use in 1920, it reached a much more significant figure in 1952 of 10.6 percent; the other is the decline in the figure for Germany. But I am sure that if you study the German trend and analyze it from other sources, you will find that the decline is only temporary. Germany--at least the western part--is certainly going to catch up and come back to more nearly its proper position.

Table 3, page 7.--Now to show you the kind of job that we have done in the United States over the past three and one-third decades, I want you to look at this table. You will notice that in the period from 1920 to 1953 our population went up from 106.5 million to 160 million, but our energy production went up from 56.5 billion to 514 billion kilowatt-hours. Population went up, in other words, 50 percent; total energy produced went up 16 times as much as population, or 800 percent; and per capita energy went up 500 percent. That certainly gives you a fairly good idea of what has been done in the way of energy availability, both to the country as a whole and on a per capita basis. It demonstrates that, at least up to the present, the United States is keeping up its expansion of power.

Chart 2, page 8.--Here we have plotted on semilog paper power production for the leading countries of the world. This shows the growth very clearly. You will find that the slope of growth for the United States up to and including 1953 is fully on a par with that of the fastest. Now that doesn't mean there is any room for complacency, but it does mean that there is room for at least reasonable satisfaction that we are certainly not falling behind and we are not standing still.

TABLE 2

ESTIMATED WORLD PRODUCTION OF ELECTRIC ENERGY PERCENT OF USE BY THE UNITED STATES AND VARIOUS OTHER COUNTRIES

IN MILLIONS OF KWH

YEAR	1920	1930	1940	1950	1952
World Production	126,000	310,000	505,000	919,000	1,106,000
U. S. Production	56,559	114,637	179,907	388,674	462,589
Percent Use:					
United States	44.9	37.0	35.6	42.3	41.8
Canada	4.7	5.8	6.7	6.2	6.2
United Kingdom	5.1	5.3	6.7	6.0	6.6
France	4.3	5.0	3.4	3.8	3.6
U.S.S.R.	.4	2.7	-	9.8	10.6
Japan	5.5	4.5	6.1	4.2	4.0
Germany	6.8	9.35	12.5	4.8 *	5.1 *

SOURCE: E.E.I.
*West Germany Only

TABLE 3

POWER PRODUCTION AND GROWTH IN POPULATION IN THE UNITED STATES 1920-1953

Year	Population (000's)	KWH Produced (000,000's)	KWH/Capita
1920	106,466	56,559	531
1925	115,832	84,666	731
1930	123,077	114,637	931
1935	127,250	118,935	935
1940	131,070	179,937	1,373
1941	133,203	208,307	1,564
1942	134,665	233,179	1,732
1943	136,497	267,540	1,960
1944	138,083	279,525	2,024
1945	139,586	271,255	1,943
1946	141,235	269,609	1,909
1947	144,024	307,400	2,134
1948	146,571	336,808	2,298
1949	149,215	345,066	2,312
1950	151,689	388,674	2,562
1951	154,353	432,319	2,801
1952	156,981	462,589	2,947
1953	159,696	513,518	3,216

CHART 2

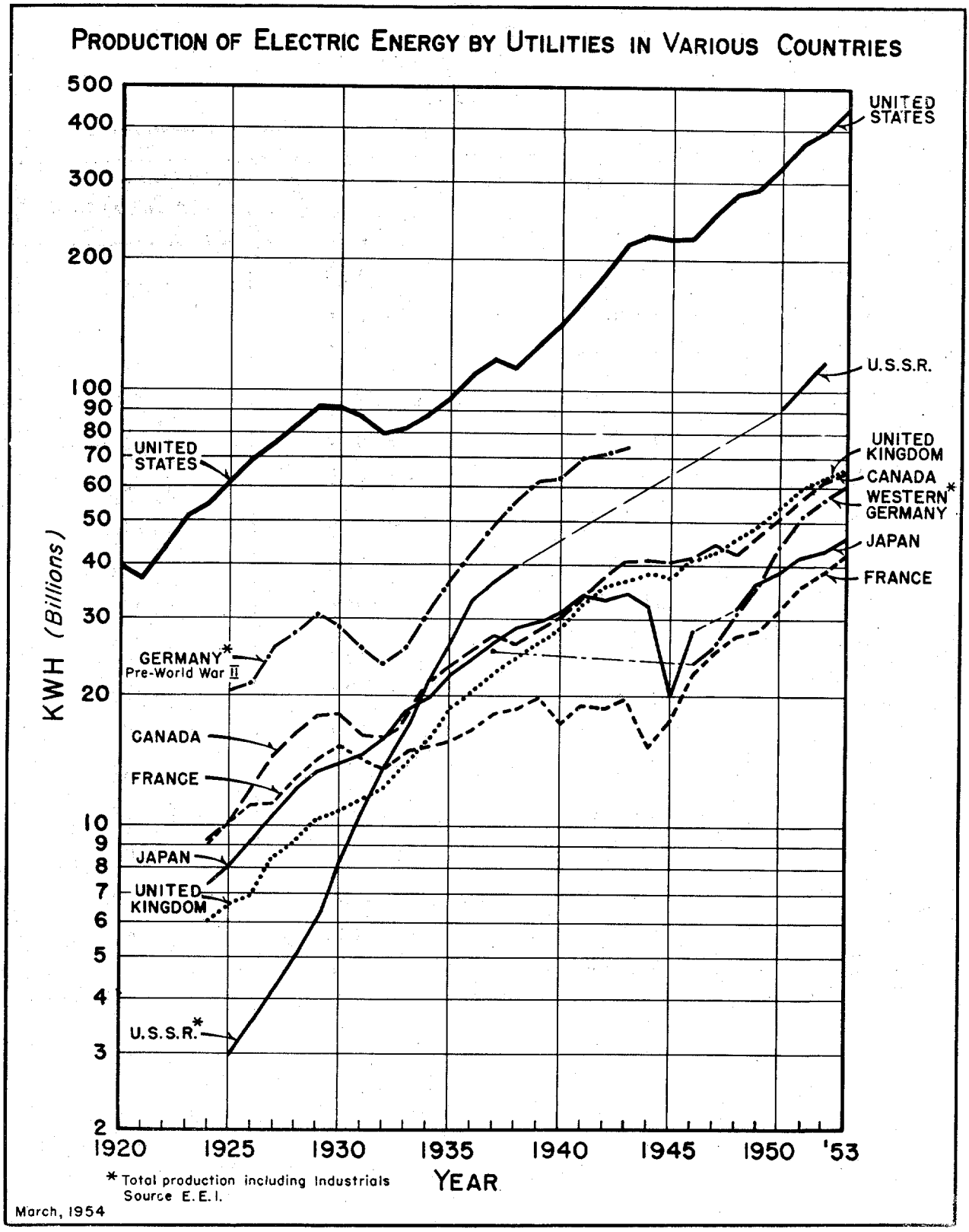

PRODUCTION OF ELECTRIC ENERGY BY UTILITIES IN VARIOUS COUNTRIES
KWH (Billions)
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1920
1925
1930
1935
1940
1945
1950
'53
YEAR
UNITED STATES
U.S.S.R.
UNITED KINGDOM
CANADA
WESTERN* GERMANY
JAPAN
FRANCE
GERMANY* Pre-World War II
CANADA
FRANCE
JAPAN
UNITED KINGDOM
U.S.S.R.*
* Total production including Industrials
Source E.E.I.
March, 1954

Table 4, page 10.--This table is merely backup data giving you the actual statistics plotted in chart 2. I would like to caution you in examining both the curves and this table to watch out for the figures of total energy and utility energy. In many cases one has been used in preference to the other, only because the basic figures were available in only one or the other form. But there is a close relationship between the two and there should be no difficulty in interpretation on the basis of the information given in these charts and tables.

There is still one other set of data to show you the job that has been done in power and the almost fantastic expansion that has taken place in electric power--how power production has contrasted with population and such other very basic items as steel, fuel, gross national product, with all of which you are concerned.

Chart 3, page 11.--Here, you will notice we have plotted for the period of the last third of a century, from 1920 through 1953, the items of population, fuel, steel, gross national product, and electric power. You can see, since this is a linear graph, the enormous difference in expansion of those fundamental entities. I think you can see this even more clearly, in table 5.

Table 5, page 12.--This is the basic information. Note, for example, that the index of power production, using 1920 as a base, for the year 1953 was 908; the gross national product index was 405; the population index, 150; the fuel production, 171 (for 1952); steel production, 236. You may observe here, however, that gross national product on the surface appears to have increased at a faster rate since 1939. Using 1939 as a base of 100, the indices in 1953 are 401 percent for gross national product versus 318 percent for power. But there is room for error in interpretation here, for while power is measured in a kilowatt-hour of constant value, gross national product has been measured in terms of a dollar of declining value.

Chart 4, page 13.--Here we have shown on semilog paper total power production, Federal Reserve Board (FRB) index of industrial production and gross national product, both on the basis of current dollars and constant 1939 dollars. This shows very clearly the effect of inflation on the current figures of gross national product. Here, using 1939 as a base, the 1953 index for gross national product in terms of constant dollars--a much better measure of actual physical output--is 196. The index for power of 318 percent is unchanged. It is obvious, therefore, that the growth of absolutely no other index even remotely approaches the growth of the index of electric power production in the last third of a century.

TABLE 4

PRODUCTION OF ELECTRIC ENERGY BY UTILITIES IN VARIOUS COUNTRIES
IN
MILLIONS OF KILOWATT-HOURS

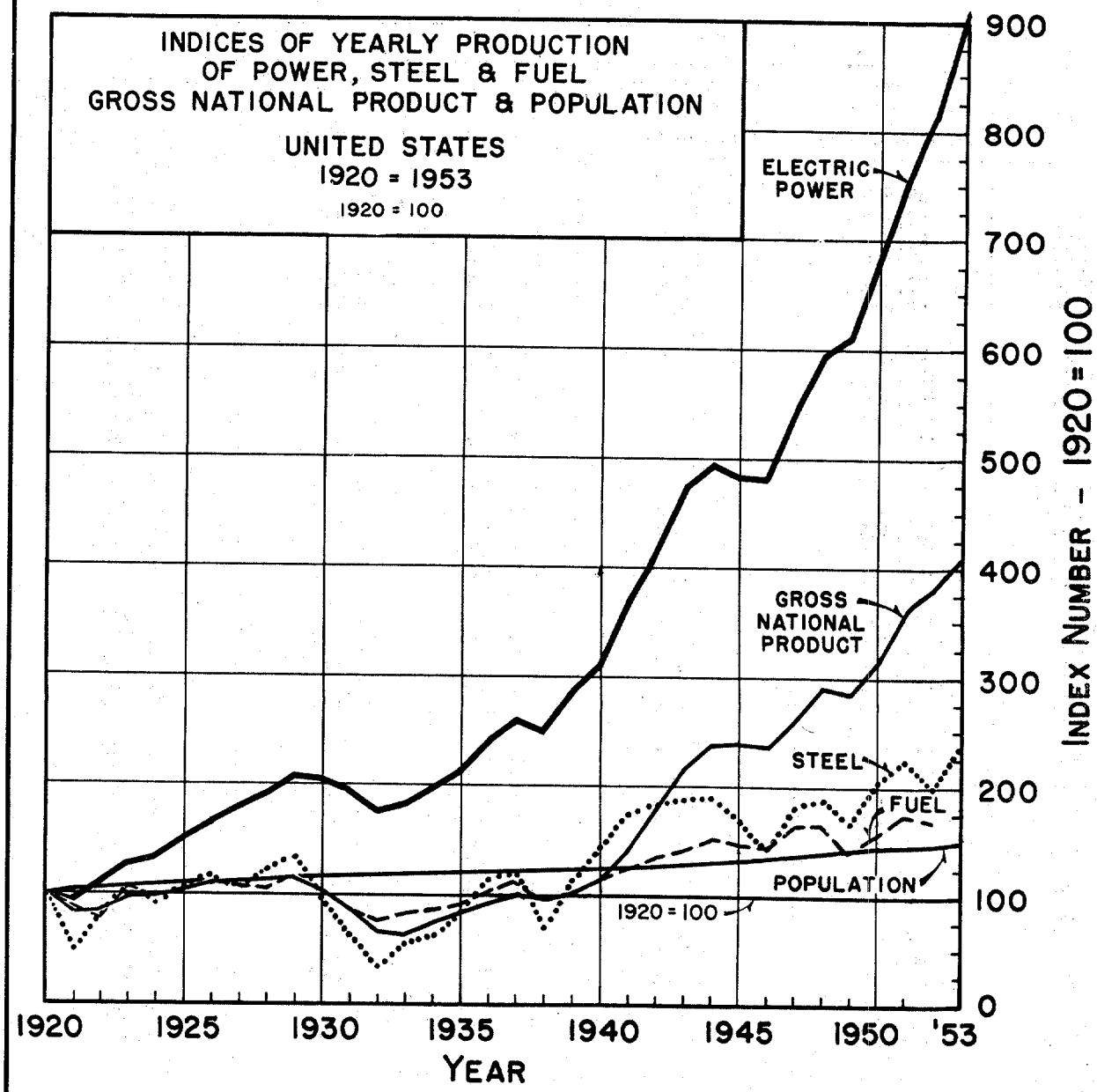
YEAR	UNITED STATES	CANADA	UNITED KINGDOM	FRANCE	U.S.S.R.[1]	GERMANY[1]		JAPAN
						Pre-World War II	West Germany	
1920	39,405							
1921	37,180							
1922	43,632							
1923	51,229							
1924	54,662	9,315	6,022	9,066				7,331
1925	61,451	10,110	6,619	10,222	2,925	20,328	-	8,172
1926	69,353	12,093	6,992	11,268	3,507	21,218	-	9,313
1927	75,418	14,549	8,452	11,388	4,173	25,135	-	10,559
1928	82,794	16,338	9,324	12,976	5,007	27,870	-	12,036
1929	92,180	17,963	10,401	14,352	6,224	30,661	-	13,312
1930	91,112	18,094	10,947	15,339	8,368	28,914	-	13,910
1931	87,350	16,331	11,533	14,232	10,687	25,788	-	14,402
1932	79,393	16,052	12,347	13,602	13,540	23,460	-	15,950
1933	81,740	17,339	13,915	14,906	16,357	25,654	-	18,160
1934	87,258	21,197	15,587	15,172	21,016	30,662	-	19,900
1935	95,287	23,283	17,971	15,818	25,900	36,697	-	22,348
1936	109,316	25,402	20,524	16,659	32,700	42,487	-	24,312
1937	118,913	27,684	22,908	18,162	36,400	48,969	25,200	26,714
1938	113,812	26,160	24,372	18,576	39,600	55,238	-	28,896
1939	127,642	28,344	26,412	19,716	-	61,380	-	29,484
1940	141,837	30,108	28,776	17,376	-	62,964	-	30,972
1941	164,788	33,312	32,364	19,044	-	69,999	-	33,444
1942	185,979	37,356	35,652	18,924	-	71,500	-	33,072
1943	217,759	40,476	36,948	19,956	-	73,943	-	34,284
1944	228,189	40,596	38,364	15,384	-	-	-	32,580
1945	222,486	40,104	37,284	17,568	-	-	-	20,064
1946	223,178	41,604	41,256	22,164	-	-	23,820	28,152
1947	255,739	44,988	42,576	25,128	-	-	25,660	-
1948	282,698	42,384	46,488	27,564	-	-	30,910	31,728
1949	291,100	46,668	49,056	28,560	-	-	35,700	36,072
1950	329,141	50,904	54,960	31,476	90,000	-	44,028	38,832
1951	370,234	57,420	59,964	36,048	103,000	-	51,360	41,112
1952	399,324	61,788	61,992	38,455	117,000	-	56,208	43,200
1953	442,014	64,991	65,512	41,966	-	-	60,200*	46,200*

SOURCE: E.E.I.

[1] Total Production including industrials

* Estimated

CHART 3



Sources: E.E.I., U.S. Dept. of Commerce, Bituminous Coal Institute

March, 1954

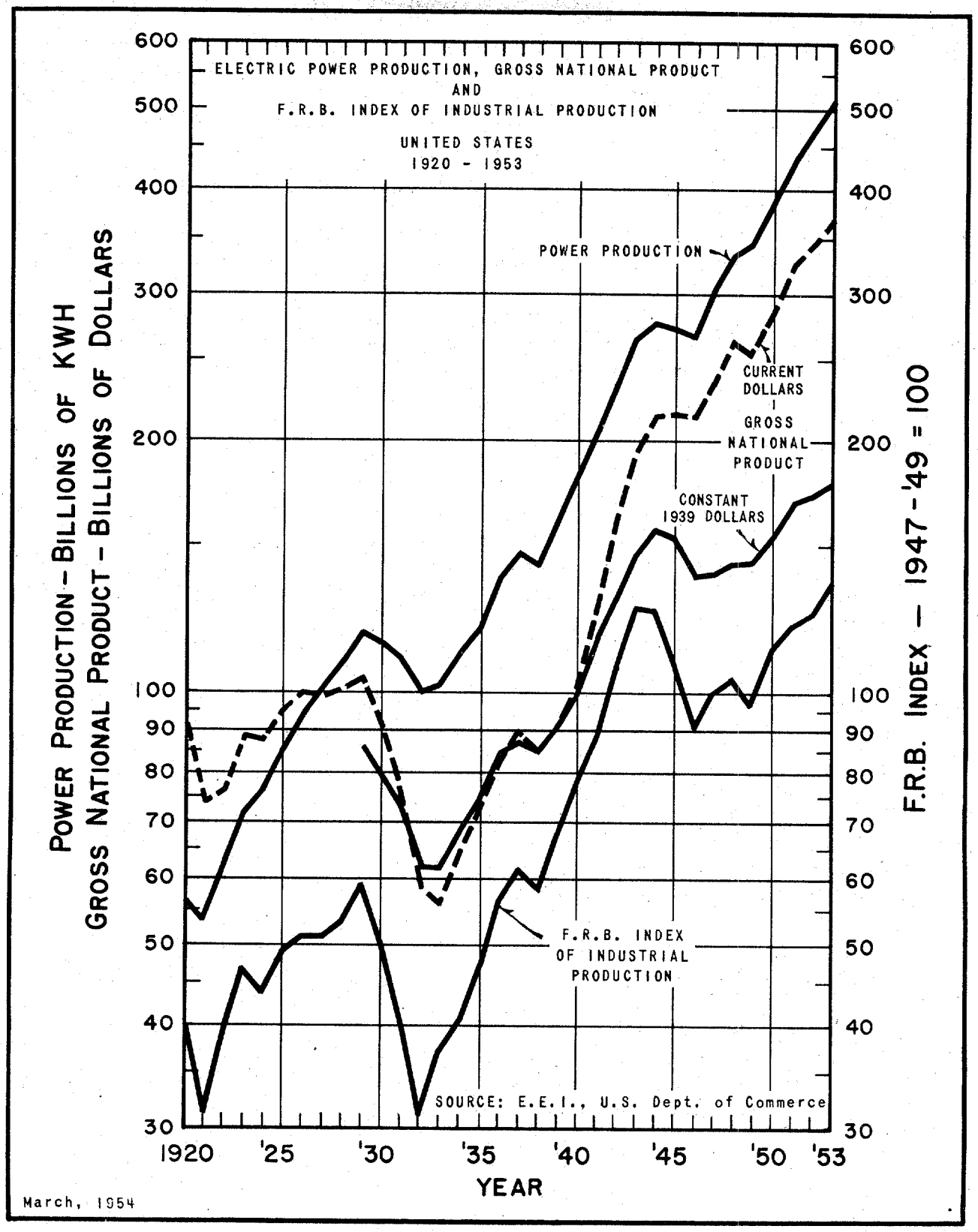
TABLE 5

PRODUCTION OF POWER, FUEL AND STEEL
GROSS NATIONAL PRODUCT AND POPULATION
UNITED STATES
1920 - 1953

Year	Power Production [1] (Millions of KWH)	Gross National Product [2] (Billions of Dollars)	Population [2] (Millions)	Fuel Production [3] of Mineral Fuels (Trillions of Btu)	Steel Production [2] Ingots & Castings (Thousands of Tons)
1920	56,559	90.5	106,466	20,602	47,189
1921	53,125	73.8	108,541	16,646	22,158
1922	61,204	75.9	110,055	16,506	39,875
1923	71,399	88.3	111,950	22,494	50,337
1924	75,892	87.4	114,113	20,274	42,484
1925	84,666	94.4	115,832	20,903	50,841
1926	94,222	99.9	117,399	23,049	54,089
1927	101,390	98.4	119,038	22,379	50,327
1928	108,069	100.2	120,501	21,949	57,729
1929	116,747	103.8	121,769	23,796	63,205
1930	114,637	90.9	123,077	21,308	45,583
1931	109,373	75.9	124,040	18,275	29,059
1932	99,359	58.3	124,840	15,607	15,323
1933	102,655	55.8	125,579	16,924	26,020
1934	110,404	64.9	126,374	18,038	29,182
1935	118,935	72.2	127,250	18,921	38,184
1936	136,006	82.5	128,053	21,598	53.500
1937	146,476	90.2	128,825	22,997	56,637
1938	141,955	84.7	129,825	19,814	31,752
1939	161,308	91.3	130,880	21,653	52,779
1940	179,937	101.4	131,070	24,089	66,983
1941	208,307	126.4	133,203	26,060	82,839
1942	233,179	161.6	134,665	28,124	86,032
1943	267,540	194.3	136,497	29,407	88,837
1944	279,525	213.7	138,083	31,572	89,642
1945	271,255	215.2	139,586	30,681	79,702
1946	269,609	212.6	141,235	29,916	66,603
1947	307,400	235.7	144,024	33,672	84,894
1948	336,808	262.4	146,571	34,409	88,640
1949	345,066	257.4	149,215	29,067	77,978
1950	388,674	282.6	151,689	32,849	96,836
1951	432,319	327.8	154,353	36,100	105,200
1952	462,589	346.3	156,981	35,171	93,168
1953	513,518	367.0	159,696		111,610

SOURCES: [1] E.E.I.
[2] U.S. Dept. of Commerce
[3] Bureau of Mines

CHART 4


ELECTRIC POWER PRODUCTION, GROSS NATIONAL PRODUCT
AND
F.R.B. INDEX OF INDUSTRIAL PRODUCTION
UNITED STATES
1920 - 1953
POWER PRODUCTION
CURRENT DOLLARS
GROSS NATIONAL PRODUCT
CONSTANT 1939 DOLLARS
F.R.B. INDEX OF INDUSTRIAL PRODUCTION
SOURCE: E.E.I., U.S. Dept. of Commerce
POWER PRODUCTION - BILLIONS OF KWH
GROSS NATIONAL PRODUCT - BILLIONS OF DOLLARS
F.R.B. INDEX — 1947-'49 = 100
600
500
400
300
200
100
90
80
70
60
50
40
30
1920
'25
'30
'35
'40
'45
'50
'53
YEAR
March, 1954

Now what in summary can we say about the electric power industry in the light of what I have shown you--the electric power industry as it is, and as it has been? It seems to me we can say this: It is quite clear that in the United States power has fully kept pace with the population and with all the requirements in war--hot or cold--and in peace such as we have today--if what we have today is that.

I think we can say perhaps something more. Over a period of the last third of a century, while the United States started with over 40 percent of the world's use of electric energy, we have kept pace and have maintained our position by producting over 40 percent of the total world's energy used, even though the world's use has expanded more than eightfold. And the per capita use in the United States in this third of a century has increased more than sixfold. All that I think can be said on the basis of the data presented in this first part.

Why Electric Power Has to Expand

I come to the next part of what I am addressing myself to and that is: Why electric power has to expand.

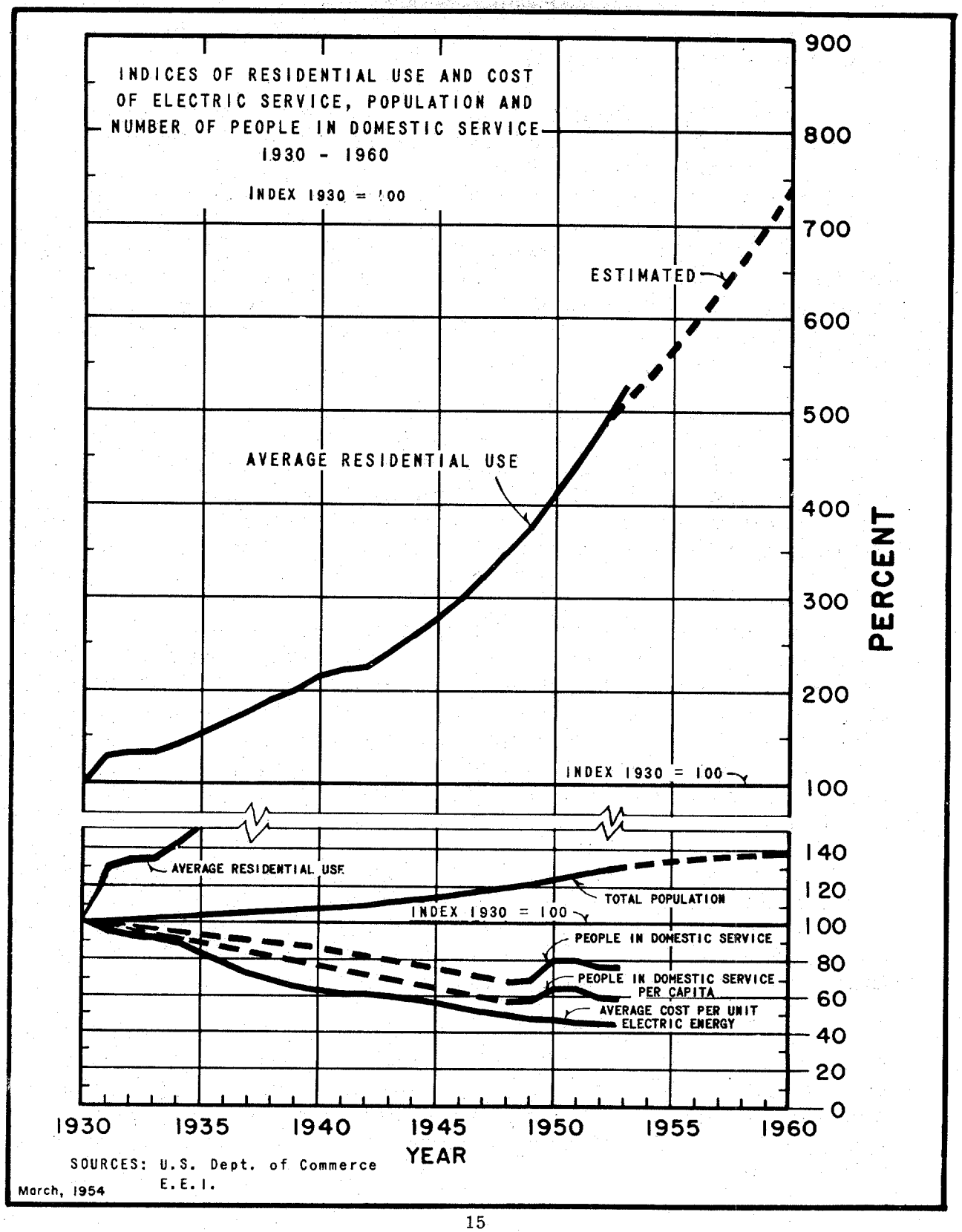
Chart 5, page15.--In this chart I have tried to show why electric power has to expand in the domestic field. The upper curve shows the actual growth on a percentage basis, using 1930 as a base of 100 in the average residential use of electric energy and population through 1953, projected to 1960. I would like you to observe the striking increase in average residential use in that 23-year period from 447 kilowatt-hours in 1930 to 2350 in 1953.

If you want to see the reason for that, I would like you to take a look at the curve, "people in domestic service," shown in the lower group of curves. The servant is rapidly disappearing from the American home. In the period shown here, the people in domestic service declined from 20.7 to 12.4 per thousand of population.

While that was going on, the substitute electric servant was becoming not only more generally available but cheaper and cheaper to hire. You can see that from the cost of electric energy curve. The cost of electric energy went down in that period from a little over six cents per kilowatt-hour to something less than three cents per kilowatt-hour. The disappearance of the domestic servant, it seems to me, has a terrific significance from the standpoint of national defense.

It seems to me that this significance comes about from the fact that the former servant has become an industrial or defense worker;

CHART 5


INDICES OF RESIDENTIAL USE AND COST OF ELECTRIC SERVICE, POPULATION AND NUMBER OF PEOPLE IN DOMESTIC SERVICE
1930 - 1960
INDEX 1930 = 100
ESTIMATED
AVERAGE RESIDENTIAL USE
INDEX 1930 = 100
AVERAGE RESIDENTIAL USE
TOTAL POPULATION
INDEX 1930 = 100
PEOPLE IN DOMESTIC SERVICE
PEOPLE IN DOMESTIC SERVICE PER CAPITA
AVERAGE COST PER UNIT ELECTRIC ENERGY
900
800
700
600
500
400
300
200
100
140
120
100
80
60
40
20
0
PERCENT
1930
1935
1940
1945
1950
1955
1960
YEAR
SOURCES: U.S. Dept. of Commerce
E.E.I.
March, 1954

an industrial worker in peacetime and a defense worker in mobilization or wartime, and the trend isn't over yet by any means. It is a trend that is bound to continue.

Chart 6, page 17.--I have shown, first, the growth in residential consumers, and you will notice what I have tried to do is to give a 15-year projection, from 1953 through 1968. Most of the growth of residential consumers will come about from the growth in population and the increase in homes. Then in the small curve in the left-hand corner at the bottom of the page, I have shown the index of the average kilowatt-hour consumption per customer, the index bringing into the home the heating device known as the heat pump. I have discussed the heat pump on other occasions before this group. I haven't too much time to go into it now.

On the bottom curve I have shown the effect on domestic use in kilowatt-hours per average residential user, depending upon three different trends in the development of the heat pump. That is, one of no development at all, therefore conventional usage; then the upper curve which shows the usage of 6,500 kilowatt-hours by 1968; and the probable figure of 5,750 kilowatt-hours by 1968 which I consider the most likely course.

Table 6, page 18.--In this table you see the anatomy of chart 6. I want merely to call attention to the fourth column on the left--Average Residential Usage. You will see here the figure of 2,270 kilowatt-hours as the average residential usage for 1953. That doesn't quite check with the 2,350 kilowatt-hours actually experienced, but this table was put together last spring and I think indicates how rapid this increase has been. I am sorry the two curves don't match, but the difference is insignificant.

You will notice the projection of 5,750 kilowatt-hours as the probable domestic usage in 1968. The figures on the development of the heat pump may be optimistic. But 5,750 kilowatt-hours per residential consumer is considerably more than twice, in fact very close to 2.5 times, the figure of domestic usage that we had in 1953.

Chart 7, page 19.--This chart shows you why I think the farm use of electric energy has to increase, and here are many significant relationships. In the first place, I have shown you at the very top the total use of electric energy on eastern farms expressed as a percentage of 1926 use. The striking increase in use is certainly clearly indicated here.

CHART 6

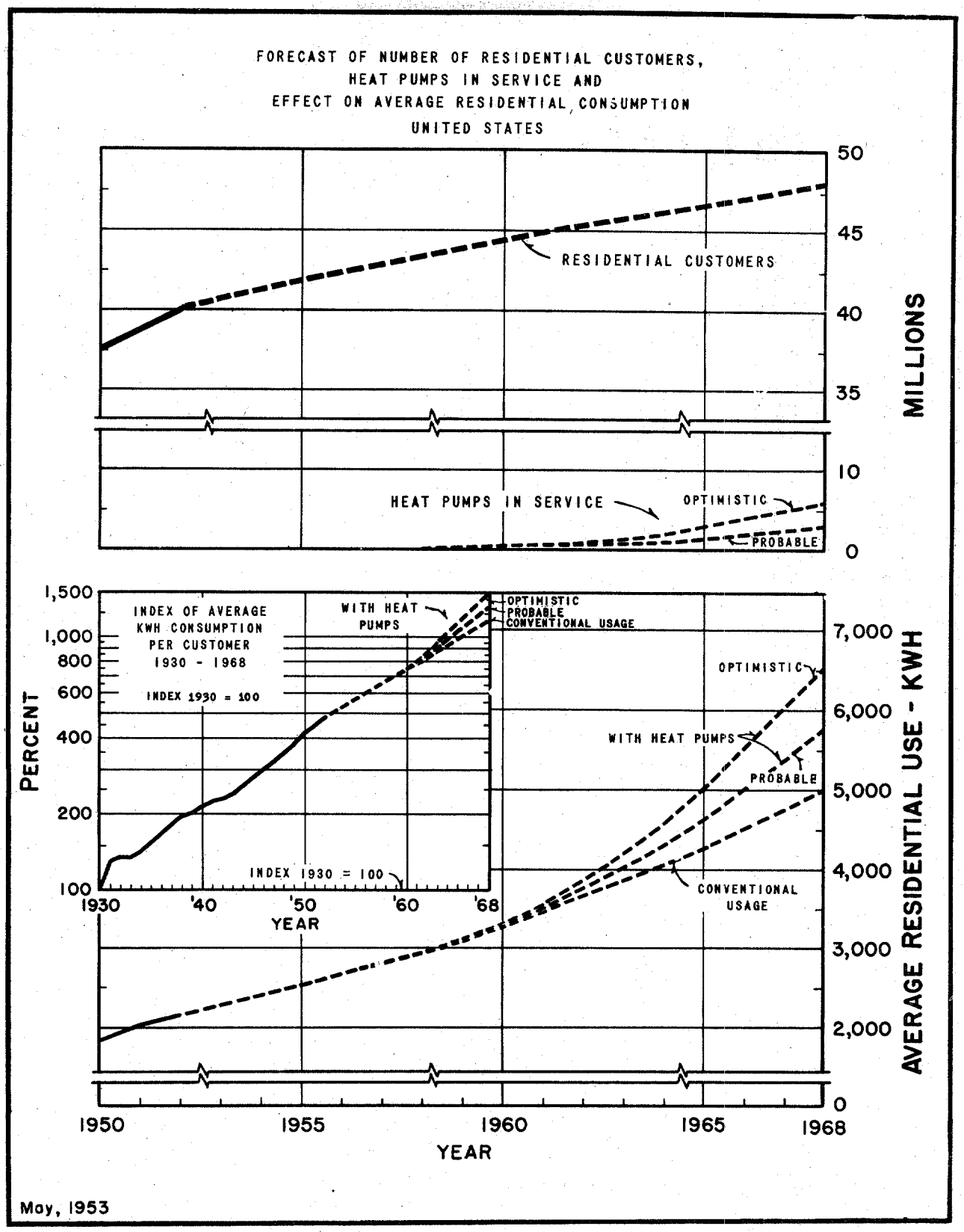

FORECAST OF NUMBER OF RESIDENTIAL CUSTOMERS,
HEAT PUMPS IN SERVICE AND
EFFECT ON AVERAGE RESIDENTIAL CONSUMPTION
UNITED STATES
RESIDENTIAL CUSTOMERS
HEAT PUMPS IN SERVICE
OPTIMISTIC
PROBABLE
MILLIONS
50
45
40
35
10
0
INDEX OF AVERAGE KWH CONSUMPTION PER CUSTOMER 1930 - 1968
INDEX 1930 = 100
WITH HEAT PUMPS
OPTIMISTIC
PROBABLE
CONVENTIONAL USAGE
PERCENT
1,500
1,000
800
600
400
200
100
1930
'40
'50
'60
'68
YEAR
OPTIMISTIC
WITH HEAT PUMPS
PROBABLE
CONVENTIONAL USAGE
AVERAGE RESIDENTIAL USE - KWH
7,000
6,000
5,000
4,000
3,000
2,000
0
1950
1955
1960
1965
1968
YEAR
May, 1953

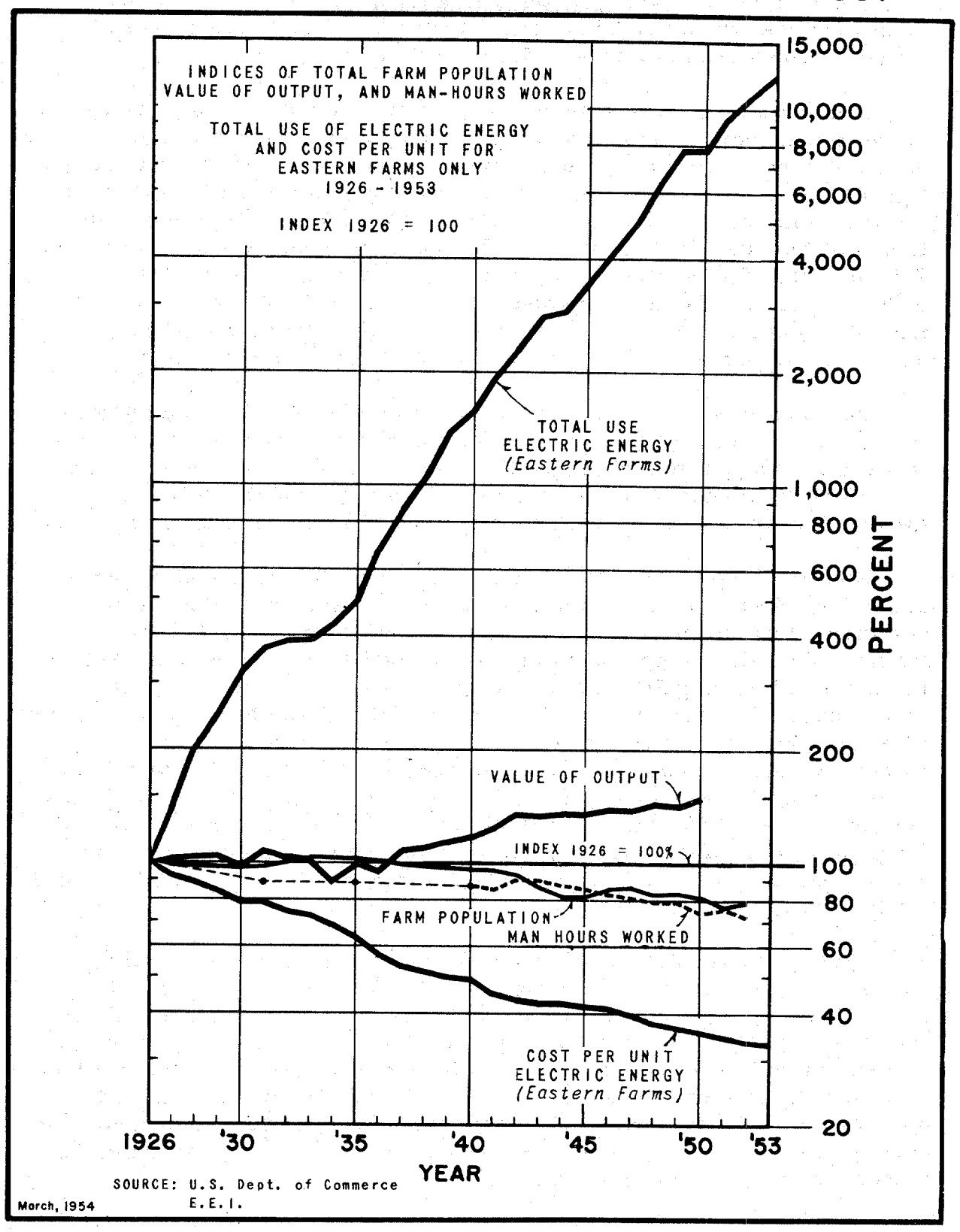
TABLE 6

FORECAST OF POPULATION - RESIDENTIAL CUSTOMERS, HEAT PUMPS IN SERVICE AND THEIR EFFECT ON AVERAGE RESIDENTIAL CONSUMPTION

YEAR	[1]Total U.S. Population (Millions)	Average Number Residential Customers All Utilities (Millions)	Average Residential Usage - Conventional Kwh	Dwellings With Heat Pumps		Effect On Average Residential Usage At 12,000 Kwh/Unit		Total Residential Usage	
				Probable (1000)	Optimistic (1000)	Probable (Kwh)	Optimistic (Kwh)	Probable (Kwh)	Optimistic (Kwh)
1950	151.7	36.6	1,830	-	-	-	-	1,830	1,830
1951	154.4	38.4	2,004	-	-	-	-	2,004	2,004
1952	157.0	40.4	2,150	-	-	-	-	2,150	2,150
1953	159.2	40.8	2,270	1	2	-	1	2,270	2,271
1954	161.3	41.3	2,390	1.5	3	1	1	2,391	2,391
1955	163.2	41.8	2,520	3	6	1	2	2,521	2,522
1956	164.9	42.4	2,650	6	12	2	3	2,652	2,653
1957	166.5	42.9	2,800	12.5	25	3	7	2,803	2,807
1958	168.1	43.4	2,950	25	50	7	14	2,957	2,964
1959	169.7	43.9	3,110	50	100	14	27	3,124	3,137
1960	171.2	44.4	3,280	100	200	27	54	3,307	3,334
1961	172.6	44.8	3,450	200	400	54	107	3,504	3,557
1962	174.0	45.2	3,640	400	800	106	212	3,746	3,852
1963	175.4	45.6	3,840	650	1,300	171	342	4,011	4,182
1964	176.7	46.0	4,040	1,000	2,000	261	522	4,301	4,562
1965	178.0	46.5	4,270	1,500	3,000	388	775	4,658	5,045
1966	179.3	47.0	4,500	2,000	4,000	510	1,020	5,010	5,520
1967	180.6	47.5	4,740	2,500	5,000	625	1,250	5,362	5,990
1968	182.0	48.0	5,000	3,000	6,000	750	1,500	5,750	6,500

[1]1953 - 1960 Population - Median Forecast-Dept. of Census.

May, 1953


INDICES OF TOTAL FARM POPULATION
VALUE OF OUTPUT, AND MAN-HOURS WORKED
TOTAL USE OF ELECTRIC ENERGY
AND COST PER UNIT FOR
EASTERN FARMS ONLY
1926 - 1953
INDEX 1926 = 100
TOTAL USE
ELECTRIC ENERGY
(Eastern Farms)
VALUE OF OUTPUT
INDEX 1926 = 100%
FARM POPULATION
MAN HOURS WORKED
COST PER UNIT
ELECTRIC ENERGY
(Eastern Farms)
15,000
10,000
8,000
6,000
4,000
2,000
1,000
800
600
400
200
100
80
60
40
20
PERCENT
1926
'30
'35
'40
'45
'50
'53
YEAR
SOURCE: U.S. Dept. of Commerce
E.E.I.
March, 1954

Please note the relationship between the curve on the value of output and the curves of farm population and of man-hours worked, which declined even faster than farm population.

It is obvious that here again is a striking example of what we have come to consider an American phenomenon, a marked reduction in hours of productive effort and a striking increase in output. The actual figures are not shown on the curve but I am giving them to you. In 1920 the farm employment was some 11.36 million and the farm output in terms of the 1939 dollar, using that constant measuring stick, was some 7.57 billion. By 1952 farm employment had dropped 14 percent, to 9.76 million, but farm output had increased to about 12.5 billion. So with a 14-percent decrease in farm employment, there was about a 65-percent increase in farm output on a constant measure basis.

How was this achieved? Obviously it was achieved by the substitution of farm power for farm labor. Some of that power--a good deal of it--was tractor power, but a good deal of it was electric power. So if you want the explanation for the productivity of the population on our farms, you want to take a look at the curve of total electric energy used.

Chart 8, page 21.--I think there is no more striking chart than number 8. Here we have, not as an index but as actual kilowatt-hours per farm, the growth in average farm use on all farms and on eastern farms. You will notice that the farms of the United States as a whole in the period of roughly 1926 to 1940 experienced a trend different from that of eastern farms alone. That characteristic was due to development of irrigation on western farms which in most cases replaced to a great extent the electric pumping load. So there was a decline in electric power use on the western farms and that affected the curve of all farms, but since about 1940, the characteristic of all farms and that of eastern farms have been about the same. The long-term trend appears to be about 7.8 percent and this trend is bound to continue for a long time into the future.

Chart 9, page 22.--Now let's look at the industrial use of electric energy. This chart shows the story behind our industrial productivity. You will note that, whereas the kilowatt-hour use per man-hour in 1940 was 4.9, by 1952 it had gotten up to 7.6, and there is every reason for believing that by 1963, it will be up to a figure of about 15, and by 1968 to about 18. It seems to me the trend here must continue. This is the only way that our national productivity and production per man-hour have been brought up in the past and the only answer we have to our need for increased productivity in the future.

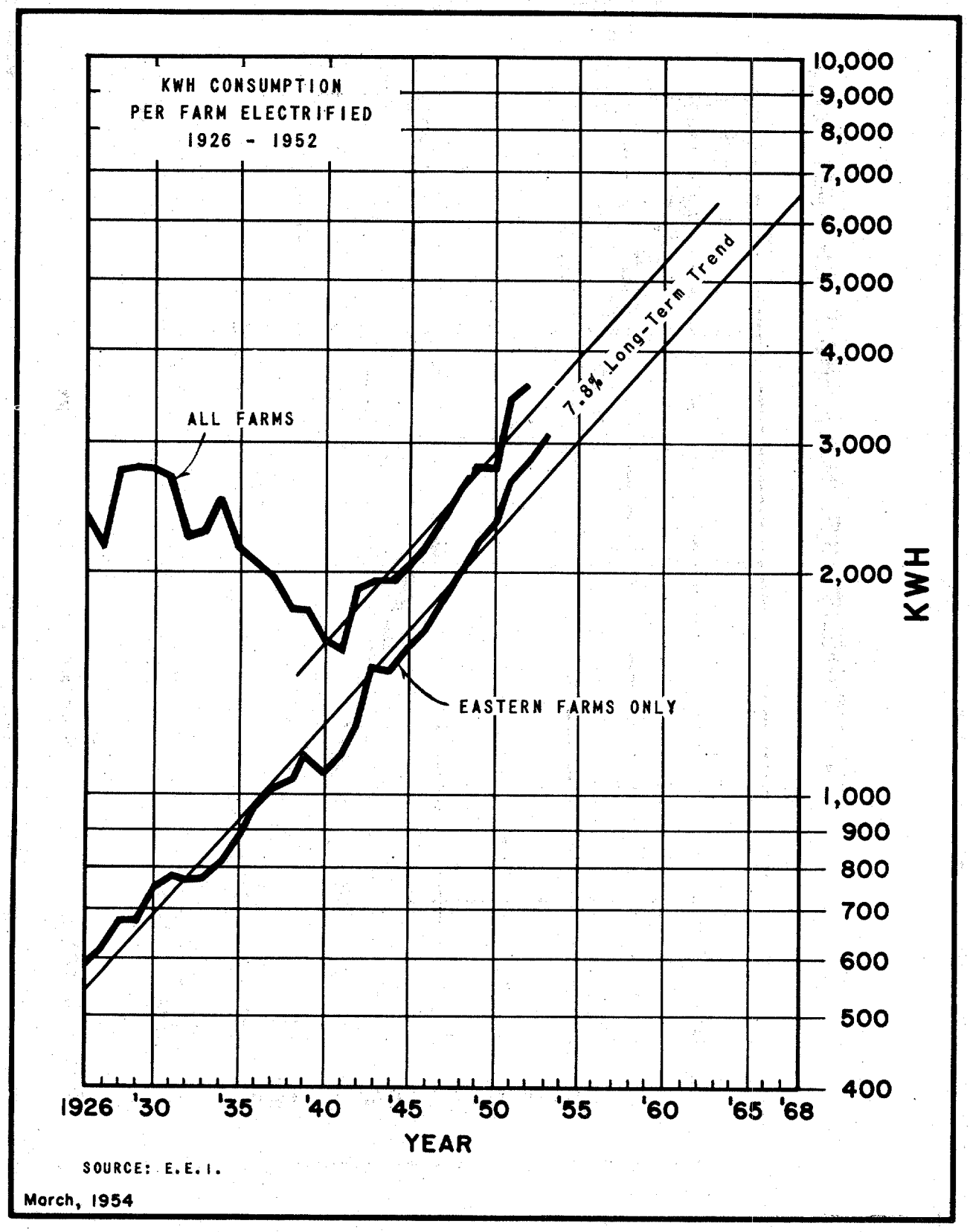
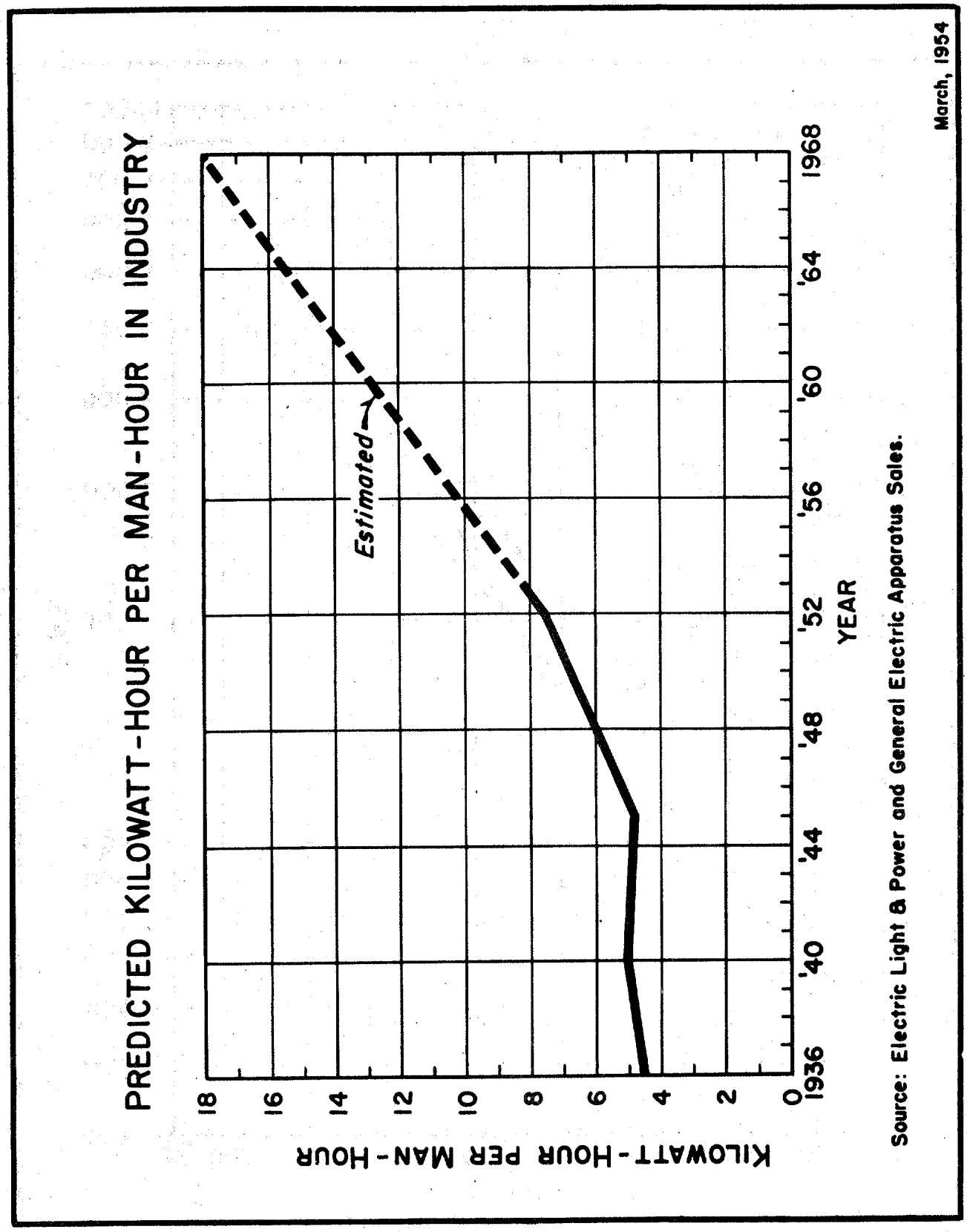

KWH CONSUMPTION
PER FARM ELECTRIFIED
1926 - 1952
ALL FARMS
7.8% Long-Term Trend
EASTERN FARMS ONLY
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
900
800
700
600
500
400
KWH
1926
'30
'35
'40
'45
'50
'55
'60
'65
'68
YEAR
SOURCE: E.E.I.
March, 1954

CHART 9


PREDICTED KILOWATT-HOUR PER MAN-HOUR IN INDUSTRY
KILOWATT-HOUR PER MAN-HOUR
18
16
14
12
10
8
6
4
2
0
1936
'40
'44
'48
'52
'56
'60
'64
1968
YEAR
Estimated
Source: Electric Light & Power and General Electric Apparatus Sales.
March, 1954

Tables 7 and 8, page 24. --Another reason why our electric power use has to expand is what I would call our exhaustion of fuels, particularly our present mineral fuels. Tables 7 and 8 show that there has been and is an increasing tendency to use our fuel reserves in different proportion to their availability, and this is bound to have an effect on the increased use of electric energy.

In table 7, for example, you will notice, first, that here we have shown the use in trillions of horsepower-hours of the various components of the total group. I think the figures are fairly reliable. Those responsible for them are indicated. I do question the hydro figures. I don't think hydro will maintain that percentage in 1960 that is shown for 1950, and it certainly will not increase its percentage.

In table 8 I think you will find we show this: If we continue to use our fuel reserves even at the 1950 rates shown in table 7, we will have exhausted our reserves of coal in 450 years, liquid petroleum in 14 years and natural gas in 30 years. These figures are based on the minimum reserves in each case. The minima are obviously too pessimistic. But there doesn't seem to be any question of this, that eventually in altogether too short a period--I don't know whether it will be 20 or 30 years or possibly longer, but still a relatively short period--our fuel resources, conventional mineral resources, except coal, are going to come into a very tight situation, and coal will have to pick up the burden of those fuels unless atomic power comes in and does it. The same is true of these other fuels--that is oil and gas, and hydro which can be treated as a fuel.

Table 9, page 25. --Still on the same point, this table shows the reserves as a ratio to production, for both oil and natural gas. I want to point out to you the decline of these ratios over the years in each case. This is one reason why sometimes these two fuels, oil and gas, have been called transient fuels: certainly looking at any reasonable period into the future they are bound to be classified as such.

Chart 10, page 26. --This chart shows a very interesting projection of what has been happening to the price of the various fuels, and I think both sets of curves shown there warrant more detailed study than I think most of you will have the time to give them. I merely want to make this point: All other fuels have had striking increases in cost over the period 1935 to 1953, except electricity. Where electricity is used as a fuel--and it is coming into use in many places--it hasn't had to contend with this rising trend and that is another basic reason why electric power has to expand.

TABLE 7

PRODUCTION OF ENERGY IN THE UNITED STATES
(Excluding wood and non-fuel uses)
IN TRILLIONS OF HORSEPOWER-HOURS

	1940	1950	1960
Hydro Electric	0.35	0.65	0.90
Natural Gas	1.10	2.30	3.85
Coal	5.00	4.85	5.30
Oil	3.10	4.90	6.80
Total	9.55	12.70	16.85
% Hydro	3.7	5.10	5.35

SOURCE: "Energy Sources" by Ayres and Scarlott

TABLE 8

ULTIMATE RESERVES OF ENERGY FROM
All Fossil Fuel Deposits of the United States
IN TRILLIONS OF HORSEPOWER-HOURS

	Maximum	Minimum
Coal	22,000	2,200
Liquid Petroleum	230	70
Oil Shale	850	140
Natural Gas	160	70
Peat	50	50
Total	23,290	2,530

SOURCE: "Energy Sources" by Ayres and Scarlott.

TABLE 9

ANNUAL PRODUCTION, PROVED RESERVES AND RATIOS OF RESERVES TO PRODUCTION FOR CRUDE OIL AND NATURAL GAS IN THE UNITED STATES

CRUDE OIL

Period	Average Annual Production Bbls X 10^6	Proved Reserves (Dec. 31) Bbls X 10^6	Ratio Reserves to Production
1901-1910	137	3,740	27.3
1911-1920	305	5,870	19.2
1921-1930	772	9,610	12.4
1931-1940	1,068	14,530	13.6
1941-1945	1,542	20,203	13.1
1946	1,726	20,874	12.1
1947	1,850	21,488	11.6
1948	2,002	23,280	11.6
1949	1,819	24,649	13.6
1950	1,944	25,268	13.0
1951	2,214	27,468	12.4
1952	2,257	27,961	12.4

SOURCE: American Petroleum Institute

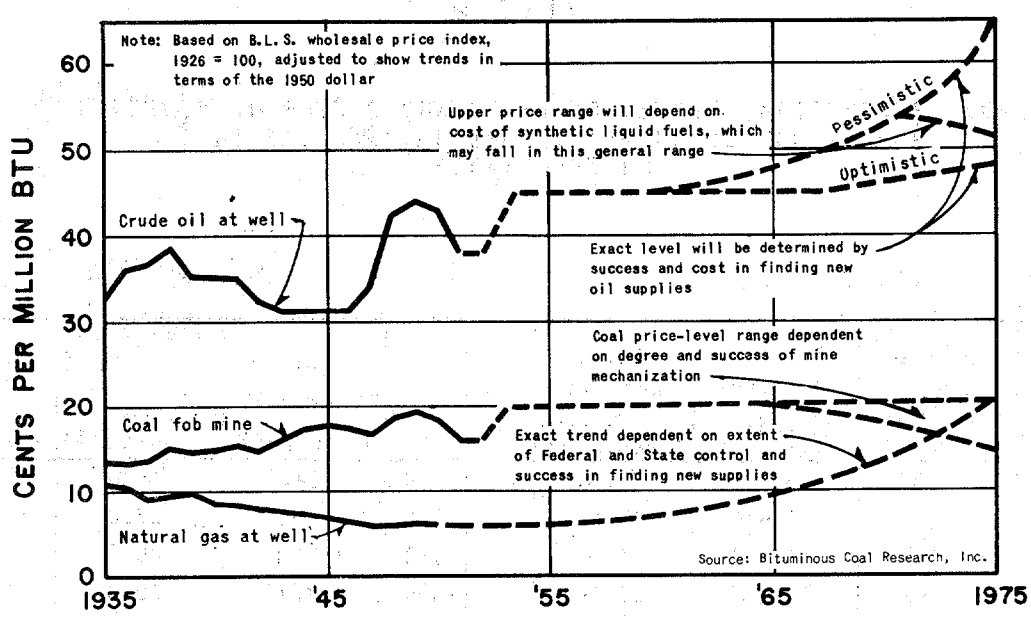
NATURAL GAS

Period	Net Production Cu Ft X 10^9	Estimated Proved Reserves (Dec 31) Cu Ft X 10^{12}	Ratio Reserves to Production
1918	746*	15.0	20.5
1925	1,189*	23.0	19.4
1930	1,943*	46.0	23.6
1934	1,771*	62.0	35
1937	2,854	66.0	23.2
1938	2,960	70.0	23.6
1940	3,331	85.0	25.6
1945	4,840	147.8	30.6
1946	5,152	160.6	31.2
1947	5,650	165.9	29.4
1948	5,958	173.9	29.2
1949	6,274	180.4	28.8
1950	7,083	185.6	26.5
1951	8,251	193.8	23.4
1952	8,862	199.7	22.3

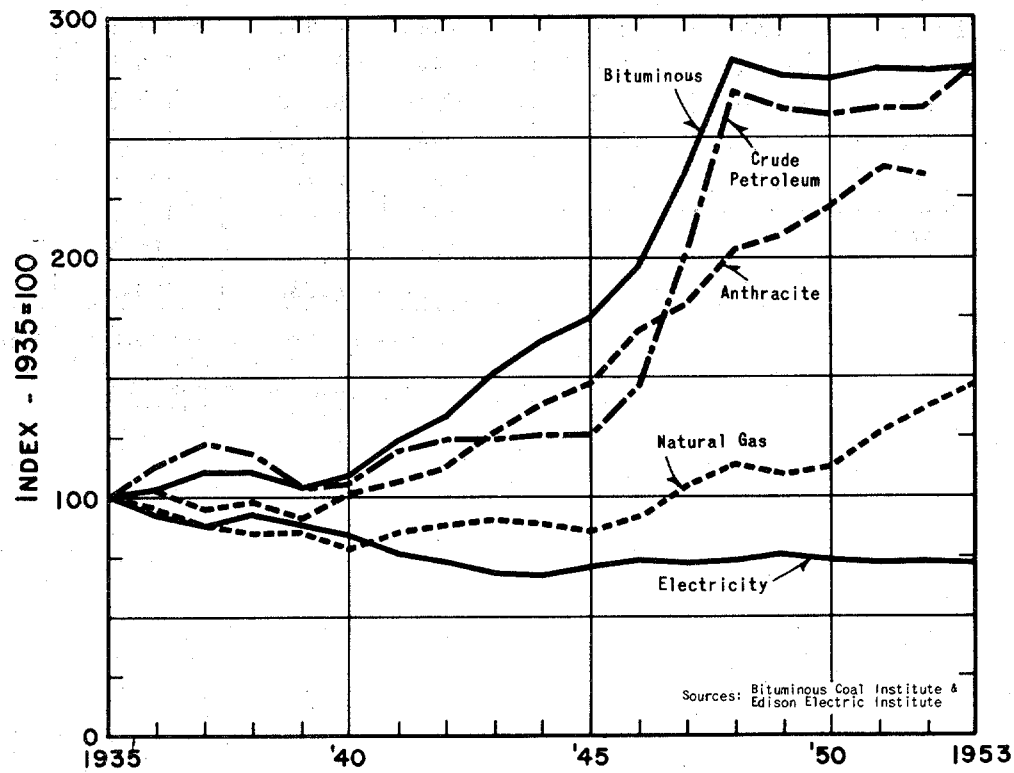
* Marketed Production— Net Production Figures not available for years prior to 1935.

SOURCES: American Gas Association
U.S. Bureau of Mines.

CHART 10



PAST, PRESENT AND POTENTIAL TRENDS IN AVERAGE UNITED STATES PRICE LEVELS OF PRIMARY MINERAL FUELS, 1935-1975



INDICES OF UNIT PRICES FOR VARIOUS FUELS AT THE POINT OF PRODUCTION AND ELECTRICITY

March, 1954

Table 10, page 28.--This table shows the world resources of fossil and nuclear fuels and I want to make this observation about it. This really, if you study it, will show you the true significance of the development of atomic power. That is, if you examine all the reserves available, world wide reserves of conventional fuels, you will find only 82.2×10^{18} Btu, or 82.2 billion billion Btu. On the other hand, the reserves available in uranium and thorium are equal to about 1,820, or roughly some 22 times that.

Now there is also this important observation, that atomic power, which is a fuel when you reduce it down to its basic character, can be exploited and will be exploited, as nearly as we can see at the present time, only electrically. For example, it is inconceivable to me that the railroads will ever go to atomic power directly or that they will be able to go by any other route than the electrical route. Perhaps if many of them saw it that way today, they would be at work on the problem from that angle.

Now I want to summarize why electric power has to expand. It seems to me electric power has to expand because in the domestic field, in the rural farm field and in the industrial field, there are deep-rooted social and economic trends or changes of relationships which make it necessary, and almost force the expansion. The thing that contributes to that is the availability of electric power and the fact that it has been available on a highly economical basis. For all of these reasons, it seems to me, electric energy is bound to expand for a long time into the future, and, because of the exhaustion of what I have called before the transient, competing fuels--oil or gas--electric energy based on coal or atomic power--either one or the other--is bound to displace them. This is the reason why electric energy is bound to expand. And it is in the national interest--that is, in the interest of national mobilization, defense and security--that it expand. As to that, I am going to show you some figures before I finish this talk.

What is Ahead in Electric Power

Chart 11, page 29.--I want to take a very brief period and show you what is ahead in electric power. In this chart I have attempted a 15-year projection of electric energy, 1953 to 1968. No matter how you look at it, whether you take a very optimistic trend--for example the 1939-1956 trend--or a more moderate trend, you come out with fantastic figures. In as short a period ahead as 15 years, with the most optimistic trend, you end up with national production in 1968 of 1,800 billion kilowatt-hours, and on the least optimistic projection, you end

TABLE 10

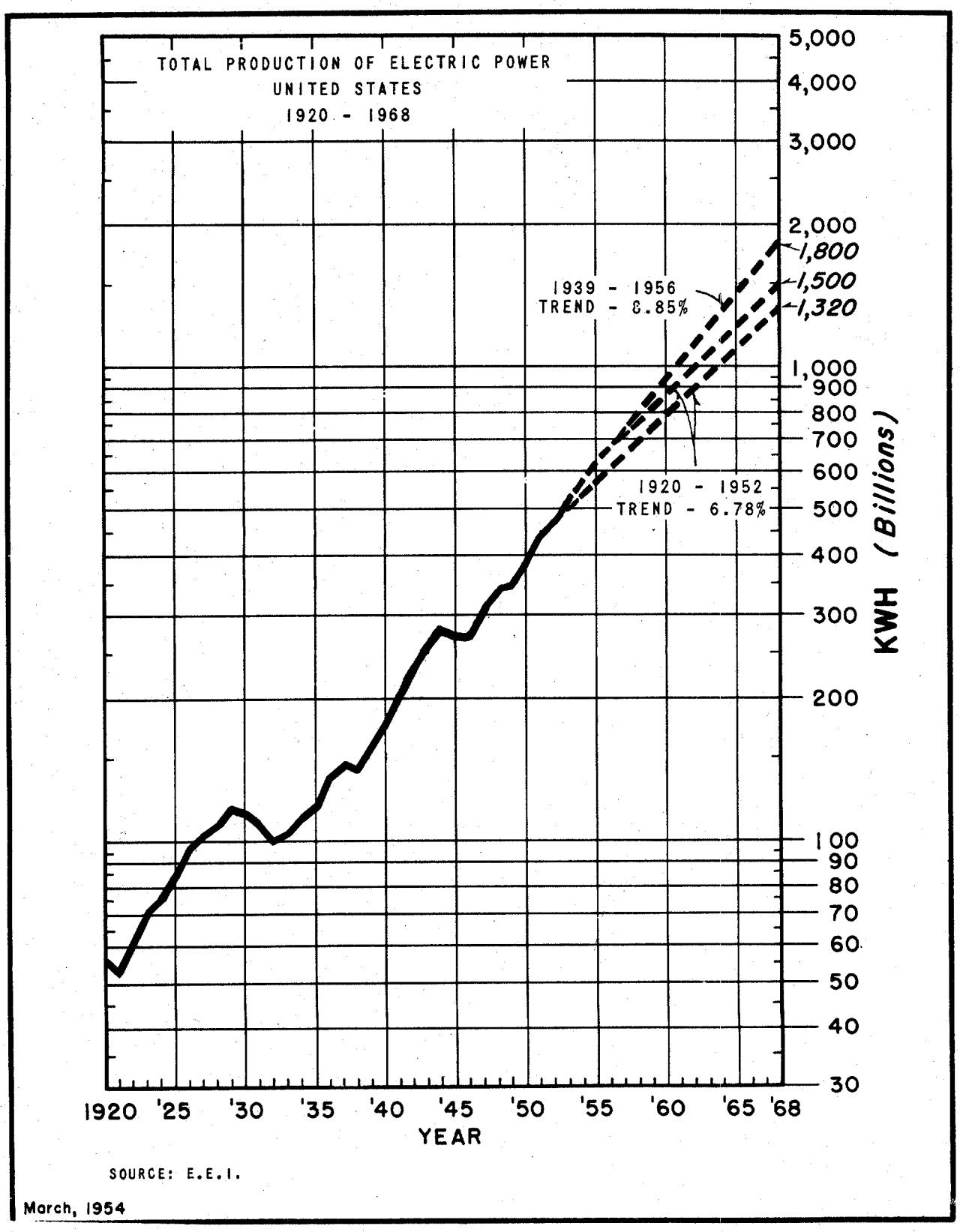
ESTIMATED WORLD RESOURCES OF FOSSIL AND NUCLEAR FUELS

FUEL	ESTIMATED WORLD RESOURCES	SOURCE OF DATA	UNIT OF ENERGY	TOTAL ENERGY Btu
CRUDE OIL	610 Billion Bbls.	L.G. Weeks	6.4×10^6 Btu/bbl.	39×10^{17}
SHALE OIL	620 Billion Bbls.	Bureau of Mines	6.4×10^6 Btu/bbl.	40×10^{17}
NATURAL GAS	2,100 Trillion cu ft	M.K. Hubbert	1000/Btu cu ft	21×10^{17}
COAL	3,482 Billion Tons	Bureau of Mines	13,500 Btu/lb 14,000 " " 9,000 " "	722×10^{17}
TOTAL CONVENTIONAL				82.2×10^{18}
URANIUM	25* Million Tons	Raw Materials Division, A.E.C.	3.5×10^{10} Btu/lb	1750×10^{18} 1 to 1 Breeding
THORIUM	1* Million Tons	" "	"	70×10^{18} 1 to 1 Breeding
TOTAL NUCLEAR FUEL				1820×10^{18}

* Recoverable at $100/lb in Billet Form

May, 1953

CHART 11



SOURCE: E.E.I.

March, 1954

up with 1,320 billion kilowatt-hours. That is from a base of 680 billion kilowatt-hours in 1956, which is pretty well visualized and which will, I think, come pretty close to being realized.

Table 11, page 31.--I want to point out to you that in any projection made, particularly on log paper, you always are likely to make a great error because a small change in slope can give you a totally astonishing change in the end result. So in this table I have shown a summary of a very complete study of all uses of electric energy, based upon the particular factors existing in each of these fields of use. I can't go into the details of the study except to say that it was done with a great deal of care and without any idea as to what the end result would be. It was very astonishing to us after finishing these figures that the projection made on that basis ended up with a 1968 figure of 1,320 billion kilowatt-hours. If you will go back to chart 11, you will see that this end figure of 1,320 billion kilowatt-hours is the result of a continuation of a growth rate of 6.78 percent experienced between 1920 and 1952. This made me feel a little bit better about the figures we projected in chart 11.

Chart 12, page 32.--This chart gives the same data as chart 11, but translated into electric utility power.

Chart 13, page 33.--This chart shows the corresponding data for peak load and capacity. I want to point out to you that in 1968--dependent upon which of these rates of growth we assume--we will end up with peak loads of 215 million, 241 million, or 304 million kilowatts demand against a 1952 figure of 75 million. The capacity needed to take care of this obviously has to be much bigger.

Chart 14, page 34.--On the basis of about 13.8-percent reserve, we have the capacity figures shown in this chart. On the top curve I have shown here these capacities: 245 million, 274 million, and 346 million kilowatts. The investments needed to bring that about are shown in the second series of curves, or 95 billion dollars, 108 billion dollars, and 137 billion dollars. The investments by investor-owned utilities--that is, taking out publicly owned utilities--are 73 billion dollars, 83 billion dollars, and 104 billion dollars. That is against the 1953 figure of 27 billion dollars. This means an increase of, at the very minimum, 2.7 times, and at the maximum 3.85 times. In other words the indications are that the investment in this short period might have to be quadrupled. So much for the capacity that will have to be built.

Chart 15, page 35.--I want to show you one or two other things that you can look forward to in the way of technological developments. In

TABLE II

FORECAST OF ELECTRIC ENERGY CONSUMPTION BY VARIOUS CLASSES OF CUSTOMERS

	ACTUAL			FORECAST			
	Millions of Kilowatt-Hours						
CLASSIFICATION	1940	1950	1952	1955	1960	1965	1968
RESIDENTIAL OR DOMESTIC	23,318	67,030	87,030	105,500	147,000	216,000	276,000
RURAL	1,991	7,400	8,519	10,650	15,500	22,500	28,200
SMALL LIGHT & POWER	22,373	50,446	62,150	75,500	104,000	144,000	175,000
LARGE LIGHT & POWER	59,557	139,065	167,450	203,000	280,000	388,000	472,000
STREET & HIGHWAY LIGHTING	2,048	2,976	3,530	4,000	4,820	6,050	6,850
OTHER PUBLIC AUTHORITIES	2,720	7,163	8,506	10,830	16,220	24,300	31,000
ELECTRIC TRACTION	5,909	5,882	5,402	5,300	5,200	5,100	5,000
INTERDEPARTMENTAL	727	578	481	480	480	480	480
TOTAL UTILITY SALES	118,643	280,540	343,068	415,260	573,220	806,430	994,530
LOSSES	23,194	48,601	55,856	64,500	83,000	117,000	144,000
TOTAL UTILITY PRODUCTION	141,837	329,141	399,374	479,760	657,220	923,430	1,138,530
PRODUCTION FOR SELF USE *	38,100	59,533	64,604	78,500	131,500	150,000	182,000
TOTAL U.S. PRODUCTION	179,937	388,674	463,978	558,260	788,720	1,073,430	1,320,530

* Includes Industries, Mines and Railway Power Plants.

May, 1953

1579

CHART 12

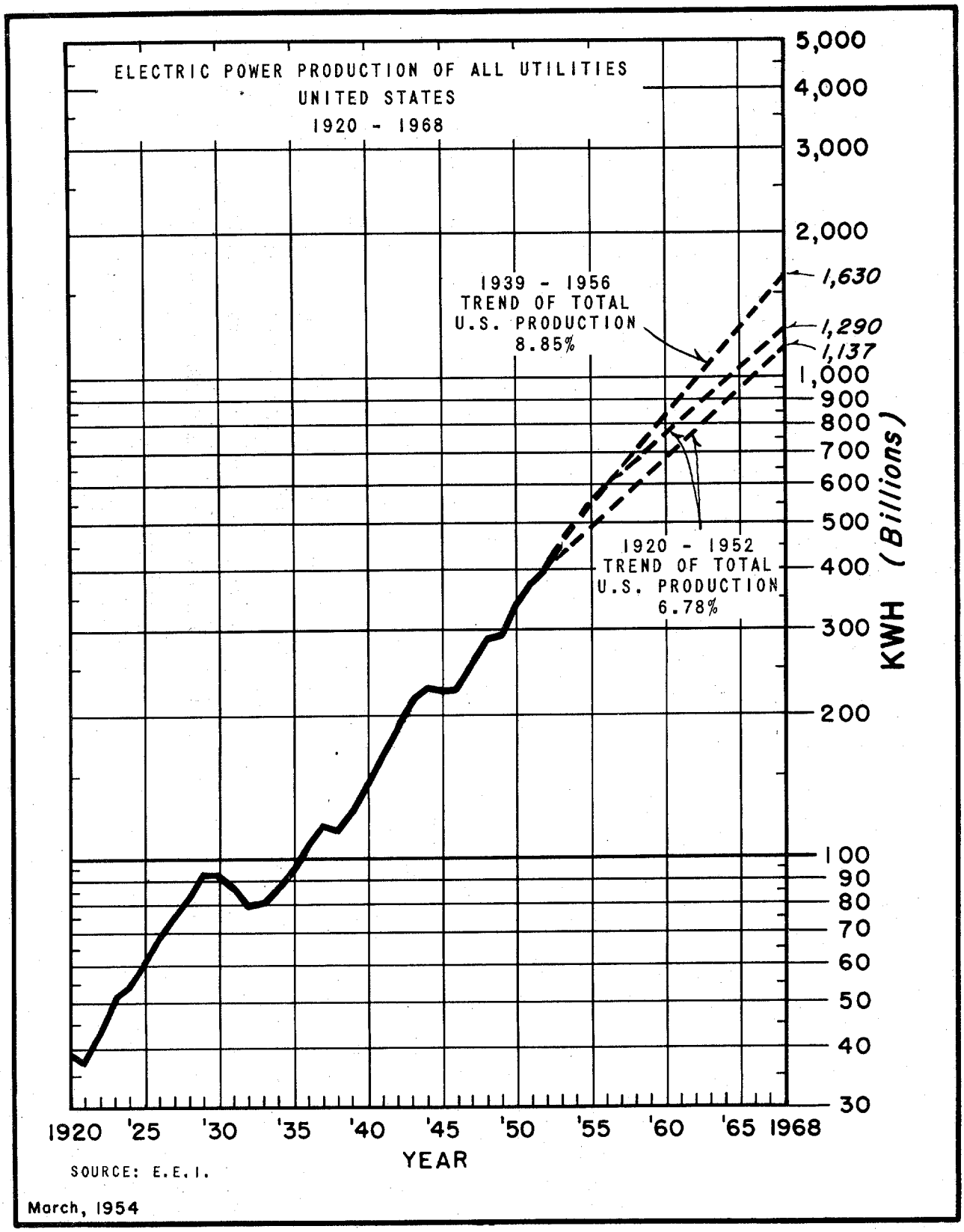

ELECTRIC POWER PRODUCTION OF ALL UTILITIES
UNITED STATES
1920 - 1968
1939 - 1956
TREND OF TOTAL
U.S. PRODUCTION
8.85%
1920 - 1952
TREND OF TOTAL
U.S. PRODUCTION
6.78%
1,630
1,290
1,137
5,000
4,000
3,000
2,000
1,000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
KWH (Billions)
1920
'25
'30
'35
'40
'45
'50
'55
'60
'65
1968
YEAR
SOURCE: E.E.I.
March, 1954

CHART 13

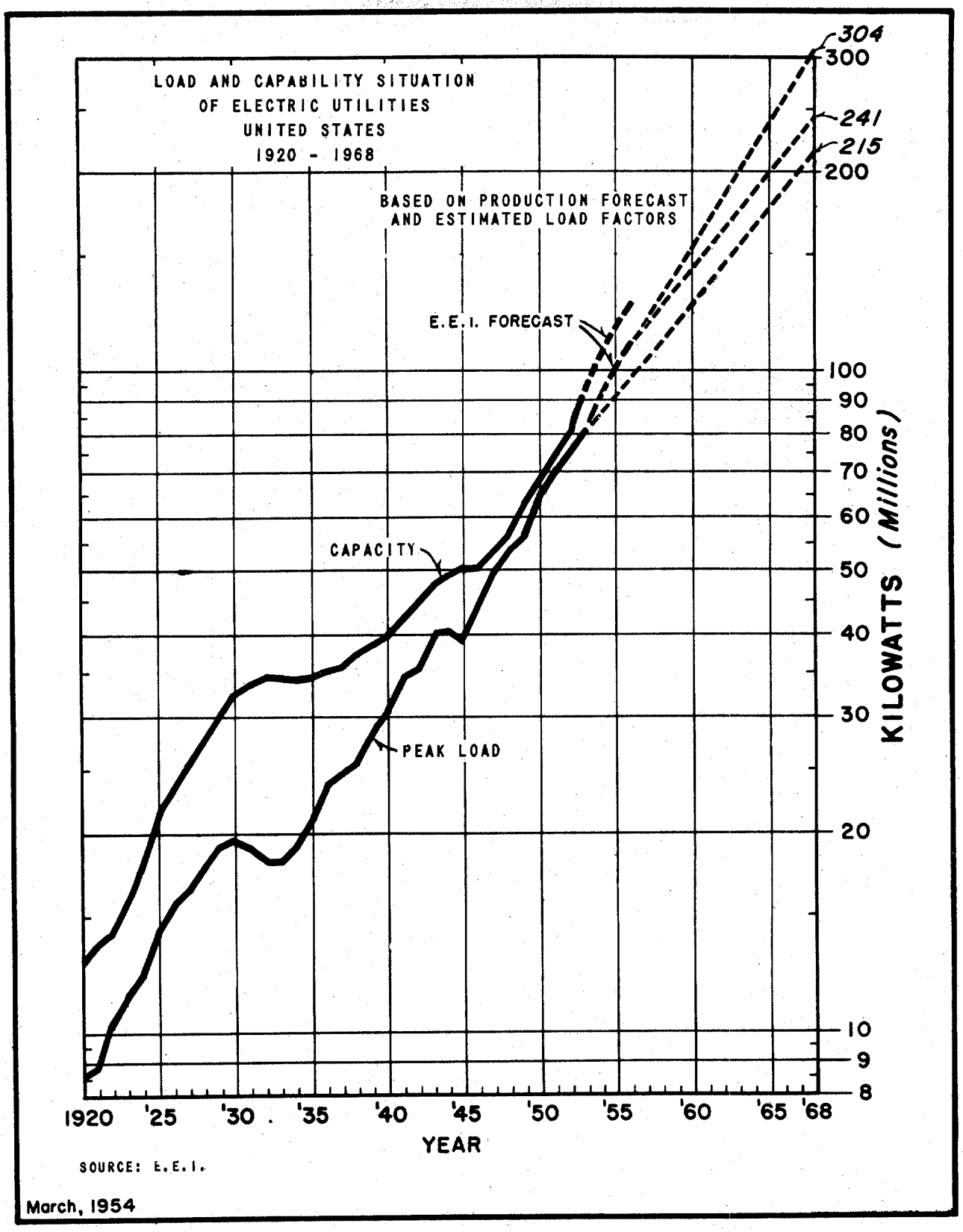
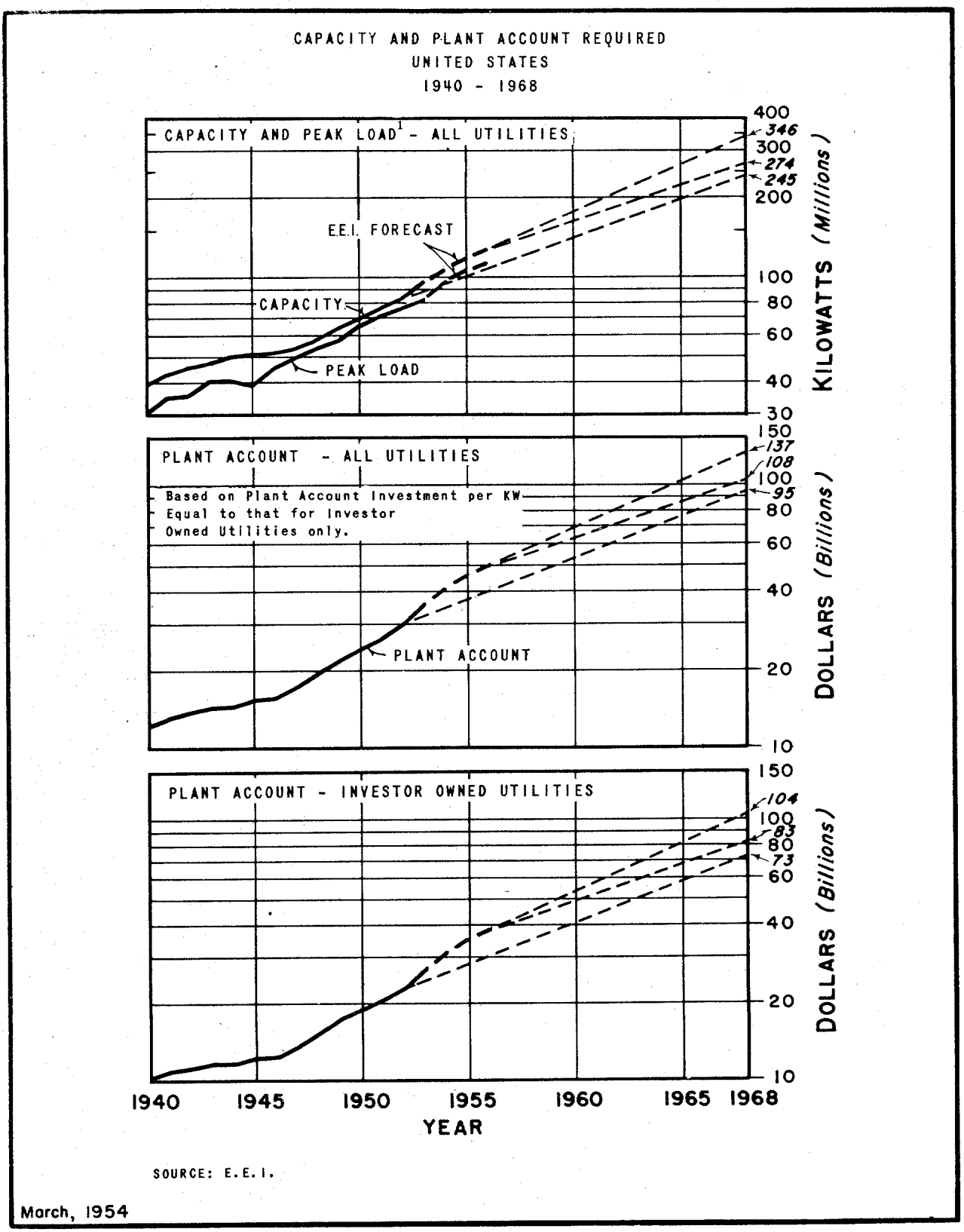

LOAD AND CAPABILITY SITUATION
OF ELECTRIC UTILITIES
UNITED STATES
1920 - 1968
BASED ON PRODUCTION FORECAST
AND ESTIMATED LOAD FACTORS
E.E.I. FORECAST
CAPACITY
PEAK LOAD
304
300
241
215
200
100
90
80
70
60
50
40
30
20
10
9
8
KILOWATTS (Millions)
1920
'25
'30
'35
'40
'45
'50
'55
'60
'65
'68
YEAR
SOURCE: E.E.I.
March, 1954

CHART 14

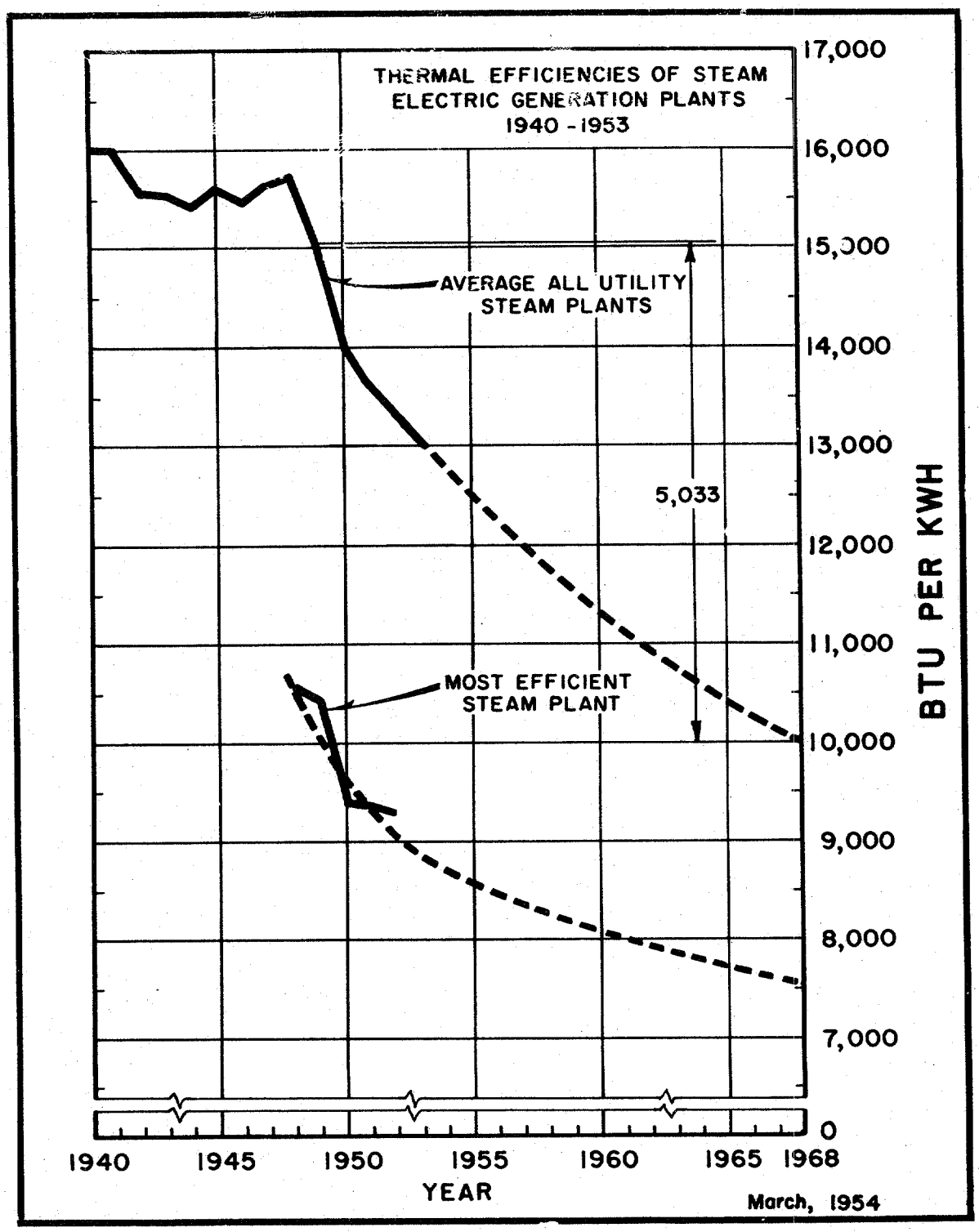


SOURCE: E.E.I.

March, 1954

CHART 15

1583



this chart I have shown one of these, and there are going to be a good many more technical changes and advances. Some of these I covered in my talk before this group last year. I also went into this subject in fairly great detail in the talk I gave before the "Mid-Century Conference on Resources for the Future" in Washington last December. Those of you who are interested might want to look at that discussion. I am going to discuss here only two items because I want to make use of them later on in this talk.

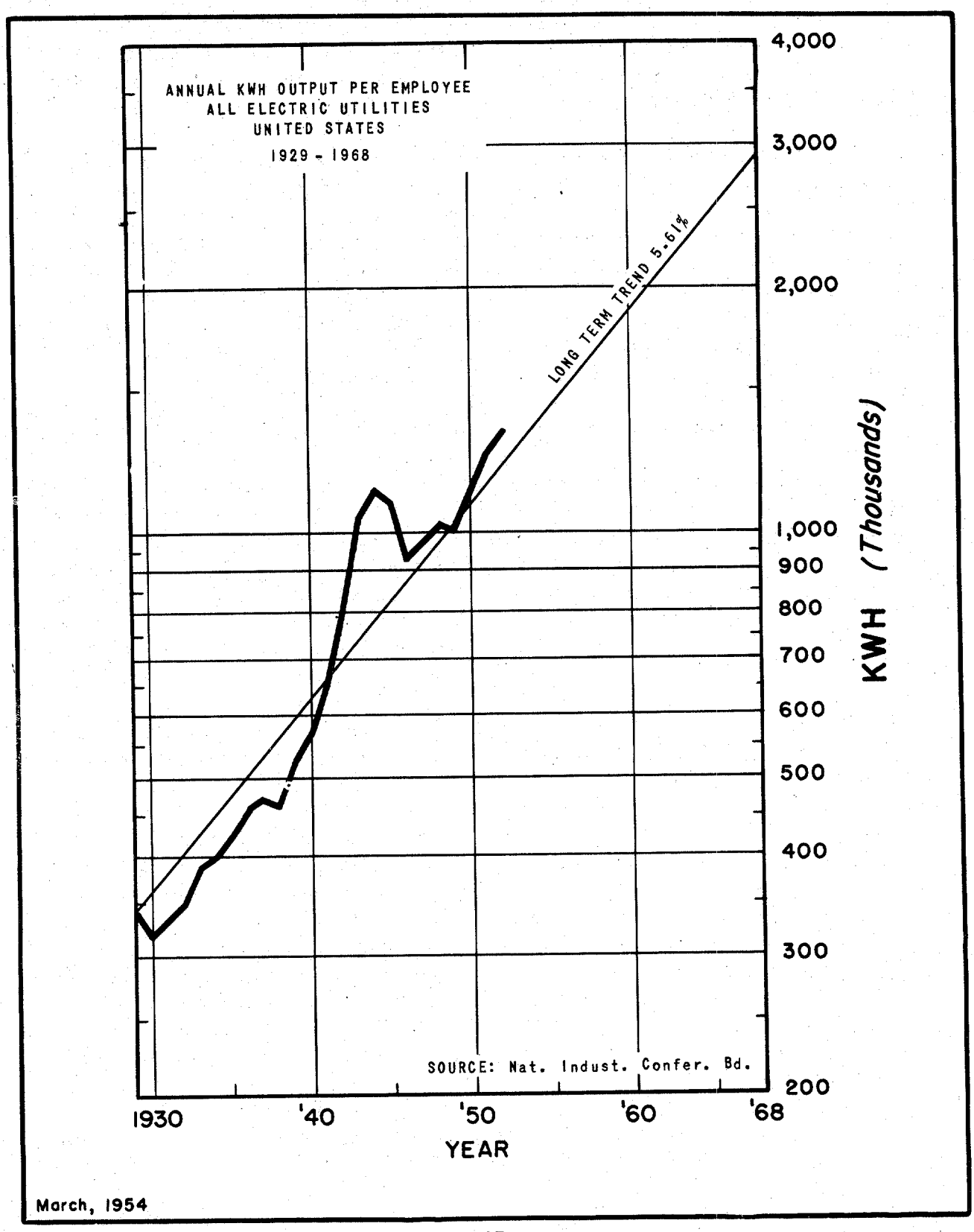
The first is the progress in efficiency in the generation of electric power. In the upper curve is shown the change that has taken place in the British thermal units of heat energy required to generate a kilowatt-hour in the 13-year period from 1940 to 1953, a reduction from 16,000 Btu to 13,000. The projection of this to 1968 shows another reduction from 13,000 to 10,000. If you ask me why I think this can be done, I want to call your attention to the second series of curves. This shows the performance of the country's most efficient steam plant, and, significantly, there is a direct relationship between the average performance and that of the new plants.

You might be interested also that in the last six years the most efficient steam plants in the United States--and I think therefore in the world--have had heat rates of 10,588 Btu per kilowatt-hour at Port Washington in 1948; 10,437 at Sewaren in 1949; 9,378 at the plant that bears my name at Graham Station, West Virginia, in 1950; and 9,354 and 9,303 at Tanners Creek in 1951 and 1952 respectively. In 1953 the Kanawha River Plant had a heat rate of 9,249 Btu per kilowatt-hour and I think that is the plant that will be shown to have been the most efficient. In the last four years the pennant has been carried by the plants with which I have had the privilege of being associated in one manner or another.

So, if you will go back to chart 15, I want to point out that we have ahead of us, first, more efficient plants. Beyond 1953, Philo No. 6 will have a heat rate of about 8,500 Btu/Kwh--slightly over 40 percent thermal efficiency--and I haven't any question that in about 10 years after that, we will be generating at a heat rate of around 7,500 British thermal units per kilowatt-hour.

Chart 16, page 37. --In this chart I have shown the advances that have taken place in the utilization of manpower in the business of energy generation. You will notice here we have plotted the curve of annual kilowatt-hour production per employee for all utilities in the United States. It is an advance that again hasn't ended, a trend that is going to continue for a long time.

CHART 16


ANNUAL KWH OUTPUT PER EMPLOYEE
ALL ELECTRIC UTILITIES
UNITED STATES
1929 - 1968
LONG TERM TREND 5.61%
SOURCE: Nat. Indust. Confer. Bd.
4,000
3,000
2,000
1,000
900
800
700
600
500
400
300
200
KWH (Thousands)
1930
'40
'50
'60
'68
YEAR
March, 1954

So when we come to a summary of what is ahead for electric power in the next 15 years, it seems to me we are going to have a terrific expansion. From a figure of 462 billion kilowatt-hours in 1952, we are going to grow to something like 1,320, and possibly to something like 1,800 billion kilowatt-hours in that short 15-year period.

This will require the most breath-taking expansion in generating capacity. It will mean the building up of capacity to a figure of from 245 million to 346 million kilowatts as against some 91 million kilowatts in 1953. And the private utilities, if they merely hold their present position, will have to build up their investments, which in 1953 amounted to 27 billion dollars, to a figure of from 73 billion to possibly 104 billion dollars. But technically the systems that we will have then will be vastly superior, and they are going to play a vital role, I think not only in national welfare but in our system of defense and security.

Some Significance of These Developments for National Security

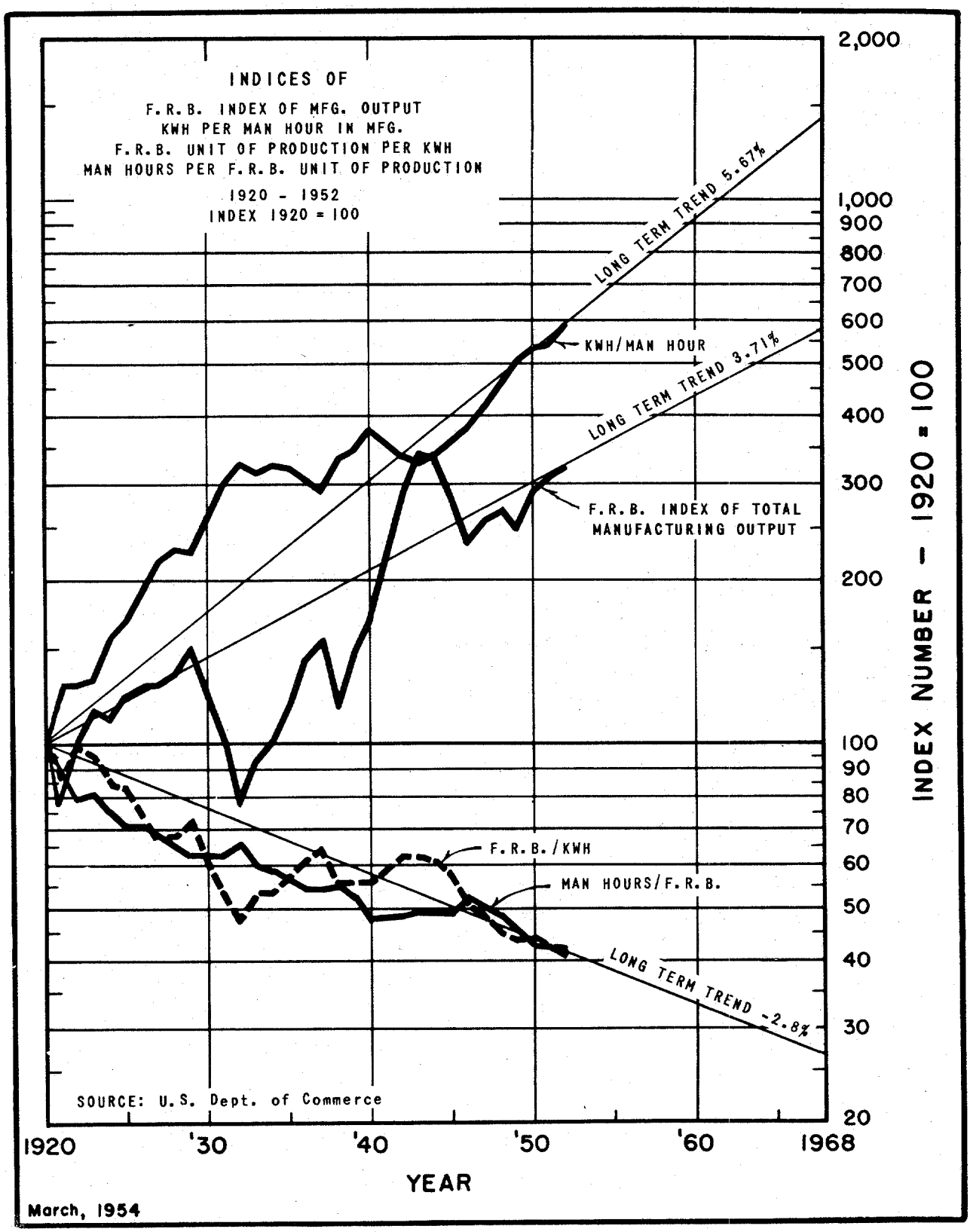
I want to show you one particular significant phase of these developments. It seems to me that the real and basic effects of electric power and some of the developments that I have been discussing with you can perhaps be expressed in an aphorism by Wendell Wilkie. Some of you may remember that he said in one of his speeches in 1940, "Only the productive can be strong, only the strong can be free." Electric power as I have shown you, is intimately--critically in fact--tied to productivity.

In the next few minutes, I would like to show you a brief capsule--and certainly nondefinitive--study of the effect of productivity and power on national security.

Chart 17, page 39.--I have shown first, in the upper curve, the kilowatt-hours per man-hour plotted on an index of 1920 as 100. In 1920 we were using only 1.28 kilowatt-hours in our industrial operation per man-hour. The 1953 figure was 8. I showed you in an earlier curve how that is going up to about 18 by 1968. But, of course, that is a terrific expansion. In the next lower curve, I have shown the increase in the FRB index of total manufacturing output. On the basis of 1947-49 production, the actual index was 39 in 1920. In 1953 it was 136. That is a significant expansion but certainly nothing like the expansion in electric power.

In the two lower curves, I have shown the unit of production (FRB index) per kilowatt-hour and the man-hours per FRB index. You will

CHART 17


INDICES OF
F.R.B. INDEX OF MFG. OUTPUT
KWH PER MAN HOUR IN MFG.
F.R.B. UNIT OF PRODUCTION PER KWH
MAN HOURS PER F.R.B. UNIT OF PRODUCTION
1920 - 1952
INDEX 1920 = 100
LONG TERM TREND 5.67%
KWH/MAN HOUR
LONG TERM TREND 3.71%
F.R.B. INDEX OF TOTAL MANUFACTURING OUTPUT
F.R.B./KWH
MAN HOURS/F.R.B.
LONG TERM TREND -2.8%
SOURCE: U.S. Dept. of Commerce
2,000
1,000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
INDEX NUMBER - 1920 = 100
1920
'30
'40
'50
'60
1968
YEAR
March, 1954

notice the two curves are of essentially the same slope. The long-term trend shows a decline of 2.8 percent. The inescapable conclusion is that our increased productivity is brought about by greater mechanization, which always means greater use of power. But essential as power is, it is not the only element, for it is mechanization that is the thing that brings about greater productivity.

Chart 18, page 41.--In this chart I have brought together these data. First, I have shown you the electric power consumption by manufacturers which appears to have a long-term trend of 6.68 percent. That is very close to the total energy trend of 6.78 percent that I showed in an earlier curve. The next lower curve, the FRB index is the same as the one in chart 17. I want to point out to you that last year we had a figure of 136, the highest figure of output in the history of this country, not even reached in the boom days of World War II. Then at the bottom I have shown you the production man-hours in manufacturing plotted back to 1920 as an index. The actual figure in 1920 was 21 billion man-hours. The 1953 figure will be very close to about 27.6 billion, but notice the difference in productivity.

So I want to come to chart 19.

Chart 19, page 42.--Here I have tried to show--please remember that I said this is a capsule study, but I think the fundamentals are sound--the estimated effects of increased electric energy consumption and increased productivity on manpower in the manufacturing, electric power, bituminous coal, and the transportation industries. I have projected the long-term trend of FRB index of manufacturing output to 1968. Based on a 1947-49 index of 100, our index in 1968 might be 224. This shows an increase in production of 3.71 percent per year.

It seems to me that this is really a measure of our strength, whether it is for peace, for defense, or for war. That is all the manufacturing output we have in the country even if we continue increasing it as we must. In peacetime we use it to satisfy our civilian wants and for defense; and in wartime we cut back peacetime use and build up the balance to the limit and use it in fighting the war. But is it really "the principal resource" for a country like ours.

Coming back to chart 19, I have shown in the next set of figures the billions of production man-hours required in manufacturing to bring about this output. If we use first the 1949 productivity levels and then project them to 1968 productivity levels, the saving in man-hours is

CHART 18

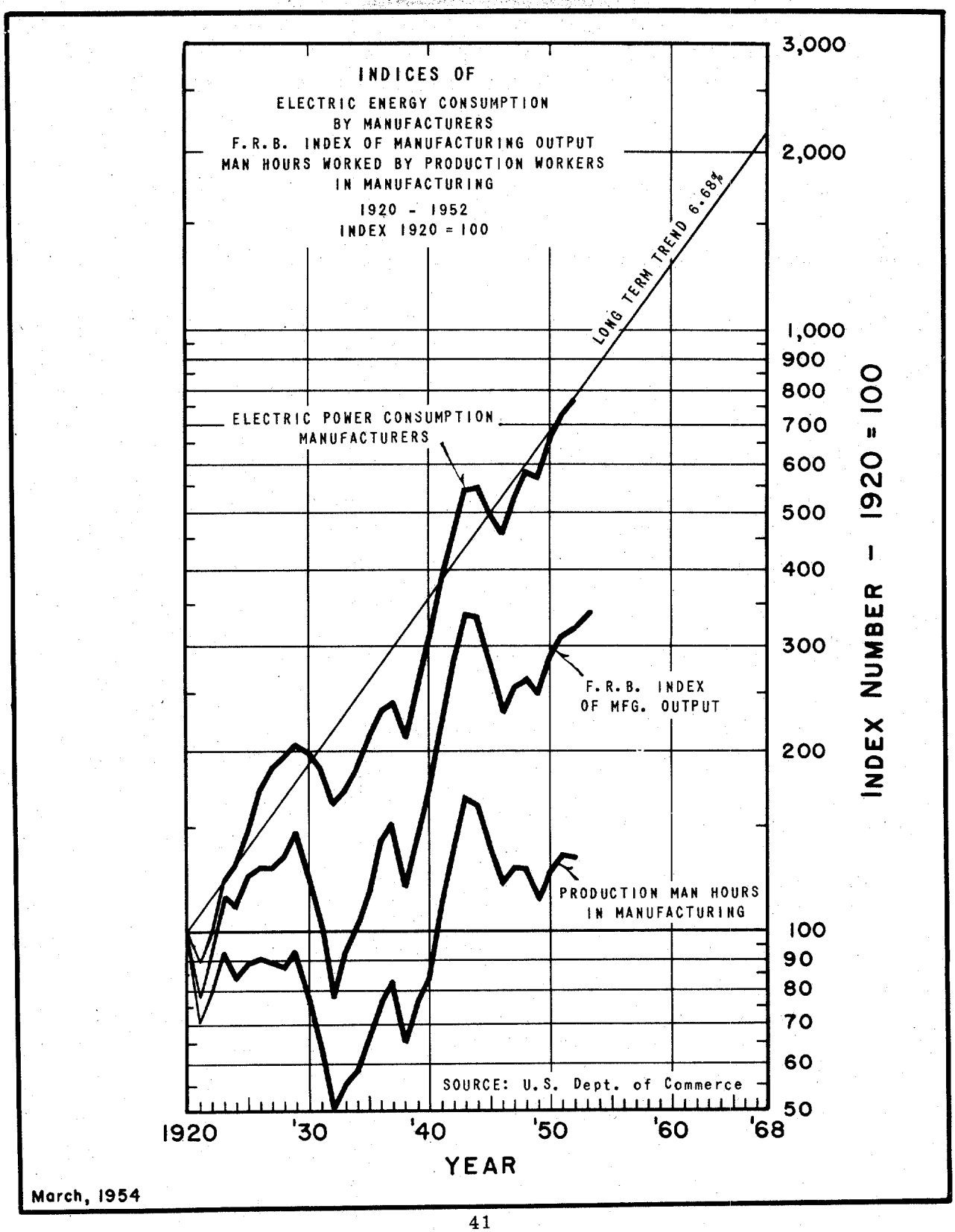


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CHART 19

ESTIMATED EFFECTS OF INCREASED ELECTRIC ENERGY CONSUMPTION AND INCREASED PRODUCTIVITY ON MANPOWER IN THE MANUFACTURING, ELECTRIC POWER, BITUMINOUS COAL AND TRANSPORTATION INDUSTRIES

Forecast 1968 F.R.B. Index of Manufacturing Output - 224 (1947-49 = 100)

BILLIONS OF PRODUCTION MANHOURS REQUIRED IN MANUFACTURING		
AT 1949 PRODUCTIVITY LEVELS	54.6	
AT PROJECTED 1968 PRODUCTIVITY LEVELS	32.0	
SAVINGS DUE TO INCREASED PRODUCTIVITY	22.6	
EQUIVALENT WORKERS AT 40 HRS. WEEKLY AVERAGE		10,850,000
ELECTRIC ENERGY REQUIREMENTS - BILLIONS OF KWH		
UTILITY PRODUCTION — 1949	291.1	
— 1968	1,137.0	
ADDITIONAL REQUIREMENTS	845.9	
ADDITIONAL EMPLOYMENT ASSUMING INCREASE FROM 1.005 MILLION KWH ANNUAL PRODUCTION PER EMPLOYEE IN 1949 TO 2.83 MILLION KWH PER EMPLOYEE IN 1968		111,000
INCREASED FUEL REQUIREMENTS IN ELECTRIC POWER INDUSTRY		
MILLIONS OF TONS BITUMINOUS EQUIVALENT:		
1949 AT HEAT RATE OF 15,033 BTU/KWH	115.2	
1968 AT PROJECTED HEAT RATE OF 10,000 BTU/KWH	348.0	
ADDITIONAL REQUIREMENTS	232.2	
ADDITIONAL EMPLOYMENT ASSUMING INCREASE FROM 6.43 TONS PER MAN-DAY IN 1949 TO 10 TONS PER MAN-DAY IN 1968 — 200 DAYS PER YEAR		84,500
ADDITIONAL REQUIREMENTS FOR TRANSPORTATION WORKERS DUE TO INCREASED FUEL REQUIREMENTS IN ELECTRIC POWER		19,000
NET SAVING IN MANPOWER		10,635,500

22.6 billion man-hours. On a 40-hour week, that means a saving of 10,850,000 men. That will require a lot more energy and therefore more men. I projected the additional manpower needed to produce this additional energy by using the projection of manpower efficiency made earlier--that is, the increasing number of kilowatt-hours produced per man-hour worked. The additional energy production will require no more than an additional 111,000 men.

It will also require about 84,500 additional men to mine the additional fuel, assuming it is going to be coal. This is based on a conservative projection of productivity in coal mining to about 10 tons per man per day, and the increase in efficiency and utilization in the power industry that I showed in previous curves. And there will be an additional 19,000 men needed in transportation as a result of increased fuel requirements, and, therefore, increased transportation of fuel. That gives us a net saving of some 10,635,500 men.

I want to point out to you that such a quick study has limitations, but I don't believe it has any basic weakness. So I think we can say this: In 1968, with the increase in production and manufacturing to a level some 130 percent higher than we had in 1949--over two and one-fourth times that of 1949--and with the continuation of the present trend in productivity, over 10 million less men will be required in 1968 to bring about that production than would be required at 1949 levels of productivity. That is what is indicated by this study.

It also shows that to make this possible it will become necessary to practically quadruple our power resources. That will mean an investment of some 50 to 80 billion dollars by private utilities. But I want you to think of it in terms of an additional army of 10.5 million able-bodied men. These are men we will not need in the production line. That, it seems to me, is the real significance of these developments to the industrial complex that we have in the United States. Gentlemen, the title of my talk is "Electric Power--An Essential Component of National Security." Can any of you have any doubts about it? Thank you very much.

COLONEL NORMAN: Mr. Sporn is now ready for your questions.

QUESTION: My question refers to table 7, on which you show hydroelectric power in 1950 was 0.65 trillion horsepower-hours, which is about 480 billion kilowatt-hours. Comparing that to your total United States output in 1950 of all electric power of only 388 billion kilowatt-hours, I wonder what is the difference?

MR. SPORN: Well I think there is a fairly simple explanation for this, although it is not too obvious from the charts. Since we are speaking in terms of fuels in table 7, the hydroelectric energy has been converted into the equivalent fuel energy which would have been necessary to produce an equal amount of thermally generated electric energy. Thus a horsepower-hour of hydroelectric generated energy, when speaking in terms of fuel, would be equivalent to about 4.6 and 4.1 horsepower-hours of fuel generated energy in 1940 and 1950 respectively. This reflects an average conversion efficiency of 21.8 percent in 1940 and 24.4 percent in 1950.

QUESTION: Mr. Sporn, your figures and graphs here are concerned with available kilowatt capacity. They do not indicate that the capacity will always be where we need it, when we need it, especially in time of war when we might be subject to bombing or sabotage. Now from reading some of your own writings, I gathered that the solution to that is the integrated power system. How well off is the country? How are we progressing toward a truly integrated power system in the United States?

MR. SPORN: If you are going to talk about an integrated system across the United States, I don't think there is such a thing. I am not sure that the country needs it. If such an integration became desirable, I presume it would come along, but the question is whether you need to shuttle power across the country 3,000 miles from Maine to Washington. I don't think you need to. But we have integrated major regions and areas. I pointed this out in a paper before the World Power Conference as long ago as 1936. The situation is much strengthened today, that is 17 or 18 years later, and we have vast areas of the United States heavily integrated, almost completely integrated.

The problem of integration, like a lot of other problems, is not an absolute problem. You cannot solve it for all time. You cannot integrate it today and say, "Now we are integrated; we don't have to worry about that any more." Integration has to move along with the country and with the times. As the systems get bigger, as the country's use gets bigger, the integrating media and integrating facilities have to grow with it. But I believe we are moving along on that kind of basis.

QUESTION: I wonder if you could tell me what progress we are making, if any, towards national and international standardization of voltages and frequencies.

MR. SPORN: We have some reasonably satisfactory standards of voltage between this country and foreign countries. As to frequency,

I am afraid we are going to have for a long time the discrepancy brought about by the fact that the Europeans have always been on a metric system and we are on our English system, so that this country has tended to standardize on 60 cycles. At one time we had here one major 30-cycle system and a number of 50-cycle systems, but the country today is more solidly unified on 60 cycles than ever before in its history. So far as I know, there is almost no tendency in the countries on the continent of Europe to use 60 cycles.

QUESTION: Mr. Sporn, I was interested in this estimate of requirements of 50 to 80 billion dollars for expansion purposes in the next 15 years. Have you made any estimate of the manpower that will be required in connection with that expansion and the natural resources that will be required for that?

MR. SPORN: No, I haven't, but we do not believe that it is going to present any insurmountable problems because we have expanded in late years at about that rate. If you take for the 15-year period an investment of 75 billion dollars and assume it will be made on an even basis--it never will actually be that simple because our economic system does not move on an even basis--then you come up with an average annual expenditure of 5 billion dollars, and I think the economic system can take that in its stride very easily.

QUESTION: Mr. Sporn, in your opinion, what is the future of the solar furnace as an energy source for producing electricity?

MR. SPORN: I think solar heat either as direct heat through some kind of absorbing system--that is collecting and absorbing system--or through photosynthesis is something that is away ahead in the future. I think that the picture of energy that has emerged fairly clearly over the last half dozen years, particularly in the last two or three years, is a picture like this: Over the next 10 or 15 years, there will be very little change from the sources of energy that we are using at the present time. That is, we are going to be operating primarily on fossil fuels, with hydro perhaps holding about the same position it is holding today. But in the next decade, there is a good possibility of some atomic power just barely beginning to make itself felt. Beyond that, depending on economic developments that cannot be foreseen at the present time--we don't really know what the economics of atomic power are going to be except that they will be very intriguing, very exciting--there is the possibility that as the years go by, our fuel plants will pick up atomic fuel and the other fuels--coal, oil, and gas--will lose some of their position.

But as to direct solar energy, it is very far away--beyond the time when atomic power might decline as a reliable and available source. The problems in solar energy are terrific. I think it is an interesting fuel for laboratory research but not much else now.

QUESTION: Mr. Sporn, I would like to refer back to a previous question for a moment. You mentioned an expansion of from 50 to 80 billion dollars over this 15-year period. I understand that is an expansion of electric energy producing facilities and if that is so, something must be done to provide the machinery to use the energy. But can our economy produce enough machinery and equipment, and enough heat and energy consuming devices to give an expansion in the neighborhood of 50 or 80 billion dollars?

MR. SPORN: Well, let us put it on a different basis. Let us assume for a rough figure--I am not sure it is very far off--that for every dollar of energy-producing equipment five dollars of energy utilization equipment will have to be expended. Now, if you assume that, and take again my average of 5 billion dollars per year, that gives you a figure for other industrial expansion of 25 billion dollars, but I don't think that is anything to be concerned about over the next 15 years in the kind of economy we have been operating, and visualizing the kind of increase in gross national product that I have shown. I am sure today the national economy would be stronger if there were in the works an additional 10 billion dollars of expansion over what there is right now, and we are only in 1954 and not in 1968.

I do want to point out this: It seems to me that one of the great things that we can build as a very solid bastion in our system of national defense is the expansion of production facilities and productivity. Even if you visualize a major atomic war--a horrible contemplation--with 50 percent of everything that we have had accumulated over the centuries by the toil of this Nation of ours wiped out, then the amount that we will have to start out with to rebuild will depend a lot on what we have built up to then. From that standpoint alone, this expansion is essential. But of course we need expansion to keep our population gainfully employed and to keep up national morale--in short to maintain a sound economy and a sound society.

I want you to think of productivity also. I didn't go into it in these terms, but by 1968, certainly by 1978, 25 years from now, we will have a population of well over 200 million. We will have an extra population equivalent to that of all of France today. If anyone proposed to annex France to the United States today and make it a part of our economic

unit, it would be recognized as something enormous and significant in the history of the country and in the additional force that it would give us. But that essentially is what will happen in 20 years. It is almost inevitable. I don't think any of these figures on production are out of line. I want to point out that while some of that increased production can come about on a static productivity basis, it is more in our national tradition to bring it about through increased productivity.

QUESTION: Mr. Sporn, do you estimate that private capital can provide the enormous amounts necessary for this expansion program or do you feel it will be necessary for Government to step in? And may I add the question, do you feel that is desirable?

MR. SPORN: I feel industrial expansion, economic expansion, and particularly capital investment is a social economic reaction that takes place only in the right atmosphere, such as many of your chemical reactions will take place only under certain pH conditions. Speaking of power, the right atmosphere I think can be maintained on the basis of two conditions. First, that confidence will be maintained in the ability of private investment, private enterprise, to do the job that the country requires. That is up to the industry. If the industry cannot generate that confidence, nobody else can. And second, if that confidence is generated, that the people determine to maintain a favorable atmosphere for private enterprise, which is proper and fair treatment, and no unfair competition beyond that which has already taken place and to which the industry has succeeded in accommodating itself. If these two conditions are met, then I don't think there is any question that we are going to be able to carry out the kind of expansion that I have indicated, that the capital will be available, that the technical personnel will be there, and that the job will be carried out with as much credit as the job of providing this country with power has been carried through up to now. I think the story of achievement in the last third of a century in the way of power, the highlights of which I have shown here this morning, is an amazing achievement.

I do think, to answer your question specifically, that the national welfare--these requirements being met, the industry staying alert and maintaining its sense of responsibility--will be far better served by continuing our present system than by changing over to any other system.

COLONEL NORMAN: Thank you Mr. Sporn for taking your valuable time and coming down to be with us. We appreciate it very much.

MR. SPORN: It was a great privilege.

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