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PROBLEMS OF LOAD FORECASTING AND THE GENERATING CAPACITY TO MEET THESE LOADS

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Note: This text is subject to editorial revision.

Electric power is a key factor in maintaining and advancing economic strength and health. An inadequate supply of electric power can seriously retard industrial and economic progress and block the way to prosperity and better living. On the other hand, premature investment in new electric power facilities that cannot be put to prompt and profitable use will tie up funds that might better be employed for other purposes.

These are serious considerations because it takes time to plan, finance, procure equipment and construct new power facilities. Thus it is necessary to start the construction of new facilities well in advance of the time when additional power is required.

There is no magic formula by which the optimum amount of electric power for any country, or geographic area, can be determined. It is possible, however, for those familiar with and responsible for the supply of electric power in their respective areas to forecast future power needs with considerable accuracy. Such forecasts can establish a very satisfactory basis for the timely expansion of electric generating capacity and related facilities. The summation of such forecasts and expansion schedules for an entire country gives a clear picture of the expected growth in overall electric power needs and the plans for meeting these needs.

This paper describes a survey procedure developed and used in the United States of America for many years in which the forecasts and expansion schedules of the individual power systems throughout the land are collected periodically and compiled by regions and for the country as a whole. Presented along with these projections are data relating to the prevailing electric power situation as well as statistics for the past, so that trends can be clearly seen.

Similar surveys are now made regularly in Canada, Western Europe, Japan and several other countries.

A 1956 study prepared by the secretariat of the United Nations Economic Commission for Europe (ECE) on "Methods Employed For The Determination of Electric Power Consumption Forecasts" indicated that the need for surveys and forecasts is recognized by many nations, both those with capitalist enterprise structures and those with centrally-planned economies.

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The methods employed by those making such power surveys vary. Some are based on complex mathematical formulas; others are based more directly upon experience.

The ECE studies, and also the findings of the authors of this paper, lead to the conclusion that soundly developed survey forecasts are important to every nation, regardless of size, economic conditions or political persuasion.

In countries that depend chiefly upon hydroelectric power generation, interest has centered in the past largely upon the number of kilowatt hours needed in a given period of time to meet consumer requirements. In such situations, the rated capacity of generating equipment is usually adequate to carry the peak loads, but the lack of water during some periods, or restrictions upon its use, often necessitates curtailment. A measure of the kilowatt hours that may be available over a long period of time does not, therefore, assure that all loads can be carried as they happen to occur.

In the United States, the primary interest is in the probable magnitude of the peak load and the ability to carry that load. Except for very few cases which involve "interruptible" clauses in the contracts, customers want and expect to receive a continuous supply of power, adequate to meet their requirements regardless of the time of day, the season of the year or of weather conditions. Any failure to provide such service would be a matter of deep concern to the electric power company, to the customers, and to the public. Broadly speaking, the supply of energy is not a controlling factor in a country where thermal generation is predominant and where adequate fuel is available. The question there is to have sufficient generating capacity to carry peak load with an adequate reserve margin to insure against possible interruption because of breakdown or unforeseen loads.

The high rate of increase which characterizes the normal growth of electric power demands naturally leads to consideration of the capacity of manufacturers to supply generating and other heavy power equipment as needed. It is important, therefore, to know how much equipment is on order and being manufactured, how much of the manufacturing capacity has already been committed for the future and the amount of the remaining open manufacturing

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capacity.

The semi-annual electric power surveys of the Edison Electric Institute (EEI), together with data collected by the Federal Power Commission, supply these needs for detailed information in the United States. The EEI is the trade association of the investor-owned electric power companies. Since 1947 it has had an Electric Power Survey Committee, responsible for the collection, preparation and publication of the survey data.

The Committee issues four reports a year, including the comprehensive semi-annual survey reports issued as of 1 April and 1 October; an interim report as of 1 July; and a year-end summary giving operating results for the year. The latter also deals with new programmes for expansion, and the equipment production schedules of the domestic manufacturers as of the beginning of the new year.

The EEI Electric Power Survey Committee is composed of some eighteen members, each of whom is associated with a power system. The members are selected on a geographical basis so that the group represents systems in all parts of the United States. Further, each member is responsible, at least in part, for the power system planning and operating activities of the system with which he is associated.

The Committee is assisted in the collection of power survey data by some thirty area representatives of the electric power systems, all of whom are active in the planning and operations of power systems or pools. They are selected from the eight power supply regions of the United States as defined by the United States Federal Power Commission. (see map I).

The committee also has the assistance of representatives from the manufacturers of heavy electric power equipment in the United States, who provide comprehensive information concerning the manufacture of heavy power equipment.

Committee meetings are held each spring and fall. The spring meeting is attended by power system and area representatives and, while it is going on, the representatives of the equipment manufacturers meet with designated Committee members to discuss equipment matters.

This method of operation makes it possible to collect the necessary data quickly and efficiently, on an industry-wide basis, from well-established

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sources of information. The Committee also receives excellent cooperation from Government-owned power systems - Federal and non-Federal. This assures thorough coverage and highly accurate regional and national figures.

Although the information is obtained at the local level by methods that are generally similar, there is no single approach or formula. Each power system is responsible for analysing its own situation, making its own forecasts and arriving at its own decisions. The individual initiative and accountability are valuable features of the arrangement. The detailed work is done by men of experience who have the local responsibility for meeting the electric power needs of customers in their own service areas. They are closest to the situation in their own systems, in their service areas, and in the power pool with which their power systems may be associated. They have the best opportunity to study the trend in customer needs and business conditions. It would be impossible for any central staff of experts to do as well in bringing the future electric power situation in the individual areas into clear focus.

Based upon experience in the United States, with the emphasis that is made there upon direct participation and individual judgement in all aspects of national life, it is believed that the approach taken by the EEI Electric Power Survey Committee is eminently practical and capable of producing the most dependable results.

The data for the power surveys are obtained by questionnaires sent to the area representatives approximately six weeks before the effective date of the survey. The questionnaires seek data concerning capability of the power systems, peak loads, gross margins, and planned new generating facilities.

Capability of the power systems, as used in these surveys, is defined as the maximum kilowatt output of the systems with all power sources available, with no allowance for outages, and (for systems including hydro installations) with sufficient kilowatt hours to supply the energy requirements of the system.

This capability must provide for scheduled maintenance, emergency outages and system operating requirements, in addition to the estimated

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load and any unforeseen load.

The capability of existing installations is determined by the demonstrated performance of the equipment at the time of the peak load. The capability of new installations is based upon design data. Estimated capabilities of those systems served wholly or in part by hydro power sources are determined for both median and adverse hydro conditions. The capabilities of all systems normally interconnected are based upon fully coordinated operation.

Peak load is the maximum load encountered on the system during a given period of time.

Gross margin (or capability margin) represents the difference between capability, as defined previously, and peak load. Gross margin, therefore, should be of sufficient magnitude to provide for scheduled maintenance, emergency outages, and system operating requirements, if practical operating conditions are to be maintained. Any excess in the gross margin over and above the provision for these items is available for unforeseen loads.

It may be helpful at this point to review how The Detroit Edison Company plays its part in these forecasts. The Company is a member of the Michigan Pool, which includes the Consumers Power Company, the Ford Motor Company, (with important interconnected generation equipment of its own) and the municipal systems of Detroit, Lansing and Wyandotte. Each of these systems forecasts its own peak load and load curve for the current year and the years ahead, including how and when the load will occur. These data for the five systems are integrated on a pool basis to determine coincident peak load and corresponding pool capability. This summing-up, together with a statement of scheduled additons to the power plants of the pool members, is reported to the Electric Power Survey Committee.

In many parts of the world, system capability forecasts are made by totalling all power sources available or shortly to become available, and then discounting the total by allowances for possible breakdowns or other unfavourable operating conditions. In the EEI power surveys, the peak capability is forecast on the premise that all power sources will be available at the time of the peak load. Under these circumstances, scheduled maintenance outages and equipment failures that may come along

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at the critical moment are, for statistical purposes and in practice, provided for by the margins of reserve (gross margin). This method is preferred because of the inability to foresee accidental outages or other possible breakdowns. Gross margin, as defined earlier, is the difference between the system capability and the peak load.

Detroit Edison has a Load Study Committee composed of representatives from the departments of engineering, operation, control, statistics and sales. They meet regularly during the year to study month-to-month trends.

These men have at their disposal a considerable amount of statistical data about the Detroit Edison service area - population growth, movement to the suburbs, number of houses being built, plans of builders to install electric appliances, heating and cooling equipment. Similar information is available concerning farms, stores and industries in the area.

The Load Study Committee analyses these data to arrive at a detailed overall estimate of load growth in the years immediately ahead, and broadly for as many as twenty-five years into the future. This estimate in turn is used to evaluate and develop the Company's engineering plans.

Thus it is possible to anticipate increases in the use of electric power and to know quite accurately how they will affect the Company.

It is necessary to understand that electric power systems in the United States make a practice of doing more than just take care of naturally occurring additions to service demand. For example, sales promotion programmes are highly effective in stimulating the greater use of electric power in homes, farms, stores and industries - and in directing that growth in two significant respects: (1) towards the use of electric power to relieve men of toil, to improve production methods and to increase their living satisfaction; and (2) in so far as can be done while fulfilling this first condition, to promote uses of electric power and to develop rate schedules that improve system load factor.

Electric power systems in the United States put customer needs first and build up their capability accordingly to serve the resultant load, never forgetting of course that a 1 per cent increase in the system-wide load factor can mean as much as a 6 per cent increase in net revenue.

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Thus the various pool and individual system forecasts which are submitted to the EEI Electric Power Survey Committee, are based mainly upon local knowledge and experience without the use of complicated mathematical formulas. Each reporting system endeavours to stay close to the realities of the service area, as seen through many individual contacts with customers. Estimates are based on business sense. This way of seeing the problem in terms of grass-roots data and business experience, with a minimum of mathematical manipulation is of course reflected in the regional and the composite national figures.

Table 1 taken from the 28th Semi-Annual Electric Power Survey Report as of 1 October, 1960, shows the actual and anticipated conditions for the December peak load period. Figure I is a graph for the contiguous United States for the years 1948 until 1963. For the years 1948 to 1959 inclusive, the values represent the conditions which actually existed while the forecast conditions are shown for the years 1960 to 1963 inclusive.

The equipment situation, as noted earlier, is an important part of the surveys. Load growth can be met only if equipment for expanded facilities can be obtained as needed. The key items are thermal and hydraulic electric generating units, steam generators (boilers), and large power transformers, all of which require considerable time to manufacture. The amount of equipment which can be produced is limited by the available shop facilities and manpower, and several other factors.

To ensure that the supply of equipment will be adequate to meet current and future needs, the Committee keeps comprehensive records of all orders placed by the domestic power systems and others for these types of equipment, including such information as shipments made, current schedules of production and estimated open manufacturing capacity. Open capacity estimates are of special significance because they indicate what the manufacturers have in terms of tools, and personnel and time available for the manufacture of additional equipment.

The Committee surveys include the following equipment:

Large steam turbine generators - 10,000 kW and larger
Small steam turbine generators - 4,000 to 9,999 kW
Generators for hydraulic turbines - 4,000 kW and larger

/Steam generators

Steam generators - 450 psi pressure and higher
Hydraulic turbines - 5,000 HP and larger
Power transformers - 501 kVA and larger

By observing current schedules of production, together with estimated open manufacturing capacity, the total amount of equipment that can be made available in the years ahead can be determined. Comparisons of these amounts with the load forecasts show the extent to which the potential supply of new power equipment will match the actual need. The published data show the totals of all manufacturers, without individual identification.

Electric power surveys conducted by the Organization for European Economic Co-operation and by the Japan Electric Power Survey Committee include information on the production of heavy power equipment and potential capacity for the production of additional equipment in Western Europe and Japan, respectively.

SUMMARY

All nations should find it advantageous to make systematic and regular surveys of the electric power situation with reliable forecasts of future power needs and required system development within their borders.

The process is more than a statistical operation. It is the industry demonstrating its vigor and ability to work intelligently to meet its responsibility to consumers and to the nation. The reports should be made available to everyone who wishes to know the facts.

In the United States a survey committee of the Edison Electric Institute collects data from the electric power systems and power pools, throughout the country. The data covering the current year and the four subsequent years provide a forecast of generating capability, peak load, reserve margins, and annual energy requirements. Most of the system data are prepared on a pool basis because most systems are interconnected.

The power systems base their load and energy consumption estimates upon many contacts with customers at the local level. Conclusions are based largely upon business sense and experience, rather than upon precise mathematical formulas.

System expansion in the United States is based upon meeting consumer needs with ample reserve margins - an approach that works out well in a nation with predominantly thermal generating facilities and ample fuel supplies.

Information concerning the orders for heavy power equipment and open manufacturing capacity is provided by the principal domestic manufacturers of such equipment.

The results of the surveys are made available to industry, to government, and to the general public through the prompt publication of several reports each year. Thus factual information concerning the current electric power situation and the forecasts for the future are readily available at all times.

Table 1

DECEMBER PEAK CAPABILITIES, PEAK LOADS, AND GROSS MARGINS

(Median hydro conditions; thousands of kilowatts)

Regions [a]		1958 [b]	1959 [b]	% Inc.	1960	% Inc.	1961	% Inc.	1962	% Inc.	1963	% Inc.
Region I	Capability scheduled	29 479	32 192	9.2	34 608	7.5	37 258	7.7	39 598	6.3	41 229	4.1
	Peak load	24 875	26 603	6.9	28 492	7.1	30 192	6.0	31 979	5.9	33 751	5.5
	Gross margin	4 604	5 589		6 116		7 066		7 619		7 478	
	Gross margin, %	18.5	21.0		21.5		23.4		22.8		22.2	
Region II	Capability scheduled	26 936	30 154	[c]	32 126	6.5	33 451	4.1	35 230	5.3	36 905	4.8
	Peak load	21 332	23 775	[c]	25 220	6.1	26 913	6.7	28 641	6.4	30 531	6.6
	Gross margin	5 604	6 379		6 906		6 538		6 589		6 374	
	Gross margin, %	26.3	26.8		27.4		24.3		23.0		20.9	
Region III	Capability scheduled	26 675	29 282	[c]	31 398	7.2	32 666	4.0	35 866	9.8	38 793	8.2
	Peak load	21 977	22 394	[c]	25 165	12.4	27 452	9.1	29 778	8.5	32 273	8.4
	Gross margin	4 698	6 888		6 233		5 214		6 088		6 520	
	Gross margin, %	21.4	30.8		24.8		19.0		20.4		20.2	
Region IV	Capability scheduled	16 420	18 050	9.9	19 461	7.8	20 665	6.2	21 590	4.5	22 540	4.4
	Peak load	13 659	14 554	6.6	15 563	6.9	16 511	6.1	17 578	6.5	18 678	6.9
	Gross margin	2 761	3 496		3 898		4 154		4 012		3 862	
	Gross margin, %	20.2	24.0*		25.0*		25.2*		22.8*		20.7*	
Region V	Capability scheduled	15 778	18 088	14.6	19 916	10.1	21 818	9.6	22 743	4.2	24 609	8.2
	Peak load	9 541	10 351	8.5	11 536	11.4	12 570	9.0	13 815	9.9	15 037	8.8
	Gross margin	6 237	7 737		8 380		9 248		8 928		9 572	
	Gross margin, %	65.4*	74.7*		72.6*		73.6*		64.6*		63.7*	
Region VI	Capability scheduled	3 322	3 750	12.9	3 998	6.6	4 222	5.6	4 524	7.2	4 991	10.3
	Peak load	2 422	2 695	11.3	3 032	12.5	3 312	9.2	3 618	9.2	3 885	7.4
	Gross margin	900	1 055		966		910		906		1 106	
	Gross margin, %	37.2	39.1		31.9		27.5		25.0		28.5	
Region VII	Capability scheduled	11 647	12 402	6.5	12 849	3.6	14 315	11.4	14 665	2.4	15 265	4.1
	Peak load	8 871	9 300	4.8	10 678	14.8	11 469	7.4	12 378	7.9	13 109	5.9
	Gross margin	2 776	3 102		2 171		2 846		2 287		2 156	
	Gross margin, %	31.3	33.4		20.3		24.8		18.5		16.4	
East Division	Capability scheduled	1 915	2 018	5.4	2 162	7.1	2 380	10.1	2 380	0.0	2 530	6.9
	Peak load	1 533	1 527	(0.4)	1 776	16.3	1 887	6.3	2 046	8.4	2 168	6.0
	Gross margin	382	491		386		493		334		362	
	Gross margin, %	24.9*	32.2*		21.7*		26.1*		16.3*		16.7*	
West Division	Capability scheduled	9 732	10 384	6.7	10 687	2.9	11 935	11.7	12 285	2.9	12 735	3.7
	Peak load	7 338	7 773	5.9	8 902	14.5	9 582	7.6	10 332	7.8	10 941	5.9
	Gross margin	2 394	2 611		1 785		2 353		1 953		1 794	
	Gross margin, %	32.6	33.6		20.1		24.6		18.9		16.4	
Region VIII	Capability scheduled	13 914	14 497	4.2	16 247	12.2	17 218	6.0	18 955	10.1	20 473	8.0
	Peak load	10 719	12 018	12.1	13 424	11.7	14 324	6.7	15 466	8.0	16 617	7.4
	Gross margin	3 195	2 479		2 823		2 894		3 489		3 856	
	Gross margin, %	29.8*	20.6*		21.0		20.2		22.6		23.2	
Survey total for the eight regions [d]	Dec. capability scheduled	144 171	158 415	9.9	170 603	7.7	181 613	6.5	193 171	6.4	204 805	6.0
	Annual increase		14 244		12 188		11 010		11 558		11 634	
	Dec. Peak load	113 396	121 690	7.3	133 110	9.4	142 743	7.2	153 253	7.4	163 881	6.9
	Annual increase		8 294		11 420		9 633		10 510		10 628	
	Dec. Gross margin	30 775	36 725		37 493		38 870		39 918		40 924	
	Dec. Gross margin, %	27.1	30.2		28.2		27.2		26.0		25.0	
Total electric utility industry of the contiguous United States [e]	December capability scheduled	148 600	163 300	9.9	175 900	7.7	187 200	6.5	199 100	6.4	211 100	6.0
	Annual increase		14 700		12 600		11 300		11 900		12 000	
	December peak load	116 900	125 400	7.3	137 200	9.4	147 100	7.2	158 000	7.4	168 900	6.9
	Annual increase		8 500		11 800		9 900		10 900		10 900	
	December gross margin	31 700	37 900		38 700		40 100		41 100		42 200	
	December gross margin, %	27.1	30.2		28.2		27.2		26.0		25.0	

* Peak load occurred or is expected to occur in summer. [a] As defined by the Federal Power Commission. [b] 1958 and 1959 represent actual operating data. [c] Starting with 1959, Region II includes three power systems previously included in Region III. [d] These values are the sum of the regional survey totals for December and do not reflect the fact that maximum loads in some regions occur in summer as indicated. [e] These values represent the Total Electric Utility Industry in December.