PROJECT M

STANFORD UNIVERSITY

TN-61-18

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PROJECT POWER REQUIREMENTS

By

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The results of an analysis of project electrical power requirements (completed November 8, 1961) are summarized herein on a chart and Tables I, II and III, attached. These data are based on the most recent advice concerning projected laboratory operations and power demands. This material will be reviewed subsequently and particularly at the time definitive design information is available on the Beam Switchyard and End Station apparatus. Some of the material contained herein has been circulated in the project on the AC Power Systems Memorandum No. 31 (November 8, 1961).

A. CONCLUSIONS

1. Three Stages in Laboratory Growth

	Support & Service Facilities	Accelerator & Research Auxiliaries	Accelerator Operation	Research Operation	Total
Stage IA - 11 Bev* Avg. - 2 Beam Paths (Table I)					
Connected Loads, Mva	14.47	20.96	26.42	32.72	94.57
Maximum Demand, Mw**	7.13	15.55	19.60	15.40	57.68
Energy Used, Mkw hr./mo.	2.82	4.55	3.22	5.05	15.64
Stage IB - 14 Bev Avg. - 3 Beam Paths (Table II)					
Connected Loads, Mva	14.67	24.26	26.42	85.31	150.66
Maximum Demand, Mw**	8.53	17.29	19.60	54.66	100.08
Energy Used, Mkw hr./mo.	3.55	5.31	4.55	16.04	29.45
Stage II - 28 Bev Avg. - 5 Beam Paths (Table III)					
Connected Loads, Mva	17.50	34.35	99.40	168.20	319.45
Maximum Demand, Mw**	11.22	23.81	86.04	115.40	236.47
Energy Used, Mkw hr./mo.	4.93	8.68	18.31	30.75	62.67

2. Research Operations Use Greatest Energy

The loads at three stages in the growth of the laboratory are shown above. This table demonstrates that research operations are the largest part of the load: 32% in Stage IA (estimated start January 1967),

* Same basis as Stanford Linear Electron Accelerator, Hearings Joint Committee on Atomic Energy, July 14 and 15, 1959, U.S. Government Printing Office, 1959, pages 642, 643.

** See Note 1. in attached pages.

56% in Stage IB (within two years after start of Stage IA).

3. Accelerator Operating Level of Stage IA and Stage IB

The accelerator operation in Stage IA and Stage IB requires less energy as compared with the Research Operation. Refer to C-1 below for further discussion.

4. Electrical Energy Costs

Presuming an average mode of accelerator operation (11 Bev, 240 pulses per second, two research areas, two developed beam paths), the cost of electrical energy will be $2,120,000 per year (based on P.G.&.E. Co. Schedule A-13). This is shown in C-2 below.

5. Increases in Energy Requirements with Laboratory Growth

The energy requirements of Stage IB show increases over the preceding Stage IA largely because of increases in the end station research facilities. The number of beam paths is used as an index to the size of the research facilities.

B. BASIS OF ANALYSIS

Simple operating procedures are presumed and beam multiplexing is not considered. An assumption was made (see Note 11.) that the accelerator will operate on the average at the beam energy levels shown below at 240 pulses per second for 600 hours per month. This analysis does not consider the possibility that maximum demand would be scheduled for off-peak hours. Much of the results of this survey are of rough order of magnitude because this study is considerably prior to the scheduled definitive design of certain major elements such as the Beam Switchyard and End Station. For example, item C-1 below illustrates limits of variation.

C. DISCUSSION

1. Beam Energy Level

The effect of operating at various beam energy levels in Stage I, two developed beam paths, two target areas, is shown by the following example: (360 pulses per second)

6 Bev	15.4 Mkw hr./mo. total
14 Bev	21.8 Mkw hr./mo. total

In Stage II, the effect of operating at various beam energy levels, five developed beam paths, etc., is much more pronounced, as shown by the following example: (360 pulses per second)

20 Bev	62.8 Mkw hr./mo. total
40 Bev	119.5 Mkw hr./mo. total

10. Average Beam Switchyard Operation - Stage II

On the average, the beam switchyard will be operated 616 hours per month (see Note 12) as follows:

28 Bev unloaded accelerator energy level.
240 pulses per second.
Five (5) developed beam paths.
Three active
One set up
One inactive

11. Calculation for Beam and Large Magnet On-Time

Number of hours/year = 8,760 hours
0.5 hours between runs.
Average of 20 hours/run.
∴ Total time/run = 20.5 hours average
Actual beam on-time = 90 percent of available.
Approximately 8.5 percent slack, maintenance, run down and major power outage.

8,760 hours x 0.915 =	8,000 hours
Estimated number of runs/year =	400
Average time per run	X 20 hours
Total time devoted to runs/year =	8,000 hours
90 percent beam on-time	X 0.9
Beam On/Year	7,200 hours
Beam On/Month	600 hours

12. Calculation for Beam Switchyard On-Time

Beam On/Month =	600 hours
Beam Switchyard Adjust & Calibration	16
Beam Switchyard On/Month	616 hours

13. Calculation for End Station Small Magnets On-Time

Total time devoted to experiments/year	8,000 hours
End Station magnets on/year	8,000 hours
End Station Magnets on/month	667 hours

11 Bev unloaded accelerator energy (half energy level).
218 modulators in operation.
240 pulses per second.
6 Mw peak rf output/klystron.

6. Average Accelerator Operation for Period within Two Years after Beam Turn-On - Stage IB

On the average, the accelerator will be operated 600 hours/month (see Note 11) during the period of two years after Beam turn-on as follows:

14 Bev unloaded accelerator energy level.
218 modulators in operation.
240 pulses per second.
12 Mw peak rf output/klystron. (2000 hour life)

7. Average Accelerator Operation - Stage II

On the average, the accelerator will be operated 600 hours per month (see Note 11) as follows:

28 Bev unloaded accelerator energy level.
900 modulators in operation.
240 pulses per second.
12 Mw peak rf output/klystron.

8. Average Beam Switchyard Operation at Beam Turn-On for Physics - Stage IA

On the average, the beam switchyard will be operated 616 hours/month (see Note 12) as follows:

11 Bev unloaded accelerator energy level.
240 pulses per second.
Two (2) developed beam paths.
One active
One set up
One (1) pulse magnet at 120 cycles.

9. Average Beam Switchyard Operation for Period within Two Years After Beam Turn-On - Stage IB

On the average, the Beam Switchyard will be operated 616 hours/month (see Note 12) for the period of two years after beam turn-on as follows:

14 Bev unloaded accelerator energy level.
240 pulses per second.
Three (3) developed beam paths.
Two active
One set up
One (1) pulse magnet at 120 cycles.

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November 8, 1961

POWER COSTS

NOTES

1. Definition of Maximum Demand*

"The maximum demand in any month will be the maximum average power taken during any 15 minute interval in the month..."

2. Maximum Demand Estimated for Beam Turn-On for Physics - Stage IA

The maximum demand for the modulator power supplies and the beam switchyard is based upon:

21 Bev unloaded accelerator energy level.
225 of the 240 modulators in operation.
360 pulses per second.
24 Mw peak rf output/klystron.
Two (2) developed beam paths.

3. Maximum Demand Estimated for Period within Two Years After Beam Turn-On - Stage IB

The maximum demand for the period of two years after beam turn-on for the modulator power supplies and the beam switchyard is based upon:

21 Bev unloaded accelerator energy level.
225 modulators in operation.
360 pulses per second.
24 Mw peak rf output/klystron.
Three (3) developed beam paths.

4. Maximum Demand Estimated for Start of Stage II

The maximum demand for the start up of Stage II of the modulator power supplies and the beam switchyard is based upon:

44 Bev unloaded accelerator energy level.
960 modulators in operation.
360 pulses per second.
24 Mw peak rf output/klystron.
Five (5) developed beam paths.

5. Average Accelerator Operation at Beam Turn-On for Physics - Stage IA

On the average, the accelerator will be operated 600 hours/month (see Note 11) as follows:

(Stanford Linear Electron Accelerator, Hearings Joint Committee on Atomic Energy, July 14 and 15, 1959, U.S. Government Printing Office 1959, pages 642, 643.)

*Pacific Gas & Electric Co., Schedule A-13, Revised P.U.C. Sheet No. 2854-E.

Interim Plan Data
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TABLE III
ELECTRICAL POWER REQUIREMENTS - STAGE II

Estimate for the Date of Beam Turn On for Stage II
Five Developed Beam Paths - Five End Stations (w/one inactive)
28 Bev, 240 pulses per second Beam

Description	Connected Load Mva	Maximum Demand Mw (1)	Average Load Mw	Operating Hours Per Month	Energy Mkw hr/mo
Support Facilities					
Admin. & Engr'g. Building	1.00	0.60	0.40		
Test Laboratory	7.50	5.40	3.60		
Central Laboratory	4.88	2.90	1.70		
Audit, Cafeteria, Gate House	0.12	0.10	0.06		
Subtotal	13.50	9.00	5.76	730	4.205
Service Facilities					
Accelerator Shop	2.00	1.20	0.36		
General Services	0.28	0.18	0.04		
Util. Bldgs., Pump, Area Ltng.	1.72	0.84	0.60		
Subtotal	4.00	2.22	1.00	730	0.730
Accelerator & Research Auxiliaries					
Kly. Gallery & Accel. Housing	19.75	14.61	6.92	700	4.844
End Station Auxiliaries	12.00	7.20	4.00	730	2.920
Beam Switchyard Auxiliaries	2.10	1.70	1.00	730	0.730
Control Building	0.50	0.30	0.25	730	0.182
Subtotal	34.35	23.81			8.676
Accelerator Operation					
Central Cooling Tower	6.40	3.60 (4)	2.60 (7)	667 (11)	1.734
Modulator Power Supply	93.00	82.44 (4)	27.63 (7)	600 (11)	16.578
Subtotal	99.40	86.04			18.312
Research Operation					
End Cooling Tower	19.50	9.70 (4)	7.60 (10)	667 (13)	5.069
Beam Switchyard Magnets	21.20	21.20 (4)	4.79 (10)	616 (12)	2.951
End Station Magnets	115.50	78.50	38.19		22.733
Positron Area	12.00	6.00	--	--	--
Subtotal	168.20	115.40			30.753
TOTAL	319.45	236.47			62.676

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TABLE II
ELECTRICAL POWER REQUIREMENTS - STAGE IB

Estimate for Period Within Two Years after Beam Turn On
Three Developed Beam Paths - Three End Station Areas
14 Bev, 240 pulses per second Beam

Description	Connected Load Mva	Maximum Demand Mw (1)	Average Accelerator Operation: Average Load Mw	Average Accelerator Operation: Operating Hours Per Month	Average Accelerator Operation: Energy Mkw hr/mo
Support Facilities					
Admin. & Engr'g. Bldg.	0.55	0.43	0.375		
Test Laboratory	7.50	4.00	2.700		
Central Laboratory	4.10	2.60	1.000		
Audit.,Cafeteria,Gate House	0.12	0.10	0.060		
Subtotal	12.27	7.13	4.135	730	3.019
Service Facilities					
Accelerator Shop	1.00	0.60	0.200		
General Services	0.20	0.10	0.030		
Util.Bldgs.,Pump, Area Ltng.	1.20	0.70	0.500		
Subtotal	2.40	1.40	0.730	730	0.533
Accelerator & Research Auxiliaries					
Klystron Gallery & Accel. Hsg.	15.00	12.00	4.22	700	2.954
End Station Auxiliaries	7.40	4.44	2.66	730	1.942
Beam Switchyard Auxiliaries	1.50	0.60	0.36	730	0.263
Control Building	0.36	0.25	0.20	730	0.146
Subtotal	24.26	17.29			5.305
Accelerator Operation					
Central Cooling Tower	1.62	0.90 (3)	0.80 (6)	667 (11)	0.534
Modulator Power Supply	24.80	18.70	6.70	600	4.020
Subtotal	26.42	19.60			4.554
Research Operation					
End Cooling Tower	9.72	4.86 (3)	3.80 (9)	667 (13)	2.535
Beam Switchyard Magnets	9.24	3.75	1.27	616 (12)	0.782
End Station Magnets	66.35	46.05	20.55		12.727
Subtotal	85.31	54.66			16.044
TOTAL	150.66	100.08			29.455

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TABLE I
ELECTRICAL POWER REQUIREMENTS - STAGE IA

Estimate for the Date of Beam Turn On for Physics
Two Developed Beam Paths - Two End Stations
11 Bev, 240 pulses per second Beam

Description	Connected Load Mva	Maximum[1] Demand Mw	Average Accelerator Operation: Average Load Mw	Average Accelerator Operation: Operating Hours Per Month	Average Accelerator Operation: Energy Mkw hr/mo.
Support Facilities					
Admin. & Engr'g. Bldg.	0.55	0.43	0.375		
Test Laboratory	7.50	2.70	1.800		
Central Laboratory	4.10	2.60	1.000		
Audit.,Cafeteria,Gate Hse.	0.12	0.10	0.060		
Subtotal	12.27	5.83	3.235	730	2.362
Service Facilities					
Accelerator Shop	1.00	0.60	0.20		
General Services	0.20	0.10	0.03		
Util.Bldgs.,Pump,Area Ltng.	1.00	0.60	0.40		
Subtotal	2.20	1.30	0.63	730	0.460
Accelerator & Research Auxiliaries					
Kly.Gallery & Accel. Bsg.	15.00	12.00	4.22	700	2.954
End Station Auxiliaries	5.00	3.00	1.80	730	1.314
Beam Switchyard Auxiliaries	0.60	0.30	0.18	730	0.132
Control Building	0.36	0.25	0.20	730	0.146
Subtotal	20.96	15.55			4.546
Accelerator Operation					
Central Cooling Tower	1.62	0.90[2]	0.60[5]	667[11]	0.400
Modulator Power Supply	24.80	18.70	4.70	600	2.820
Subtotal	26.42	19.60			3.220
Research Operation					
End Cooling Tower	4.86	2.48[2]	1.90[8]	667[13]	1.267
Beam Switchyard Magnets	6.76	2.92	0.78	616[12]	0.480
End Station Magnets	21.10	10.00	5.16		3.302
Subtotal	32.72	15.40			5.049
TOTAL	94.57	57.68			15.637

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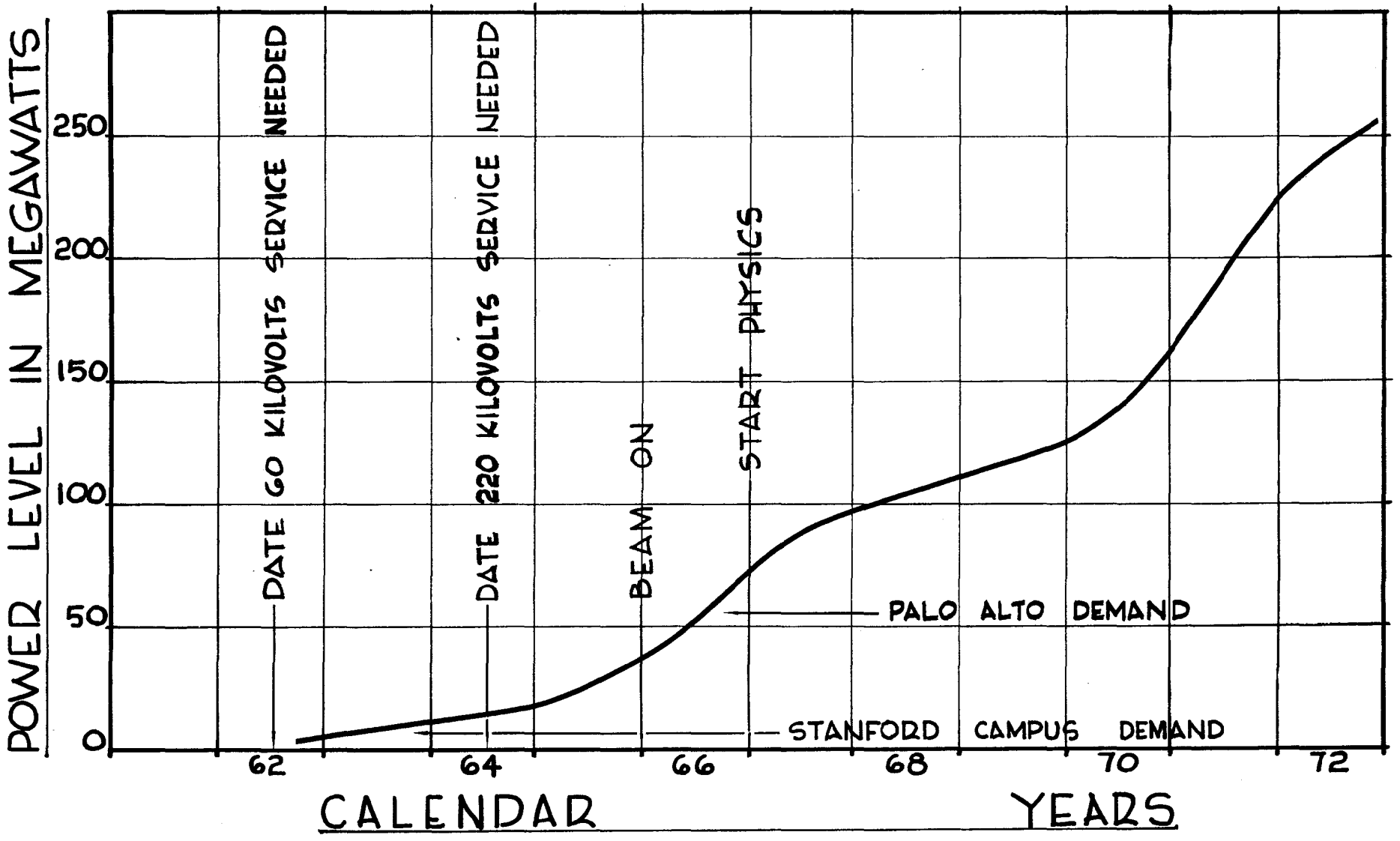
PROJECT LOAD GROWTH

MAXIMUM DEMAND



2. Estimate of Electrical Energy Costs

Stage	Beam Energy	Beam Paths	Maximum Demand Mw	Energy Used Mkw hour Per Month	P.G.&E. Schedule A-13* Unit Cost mils/kw hr.	Annual Cost 10^6/yr.
IA	11 Bev	2	57.7	15.64	11.3	2.12
IB	14 Bev	3	100.1	29.45	10.94	3.87
II	28 Bev	5	236.5	62.67	11.42	8.59

3. Load Growth

		Maximum Demand 60 kv Source Mw	220 kv Source Mw	Total Mw
July, 1962	Install 60 kv Service	X	--	X
Aug., 1962		0.5	--	0.5
July, 1963	Constr., Test Laboratory	4.0	--	4.0
July, 1964	Constr., Test Laboratory, Central Laboratory, etc.	10.0	--	10.0
July, 1964	Install 220 kv service	--	X	X
Jan., 1965		16.0	2.0	18.0
July, 1966	Accelerator Operation Test	16.0	41.7	57.7
Jan., 1967	Stage IA - Beam on for Physics	16.0	41.7	57.7
Jan., 1969 or earlier	Stage IB - Ext. of End Station	16.0	84.1	100.1
Jan., 1972	Beam on for Stage II	16.0	220.5	236.5

The above data are included on the attached "Project Load Growth, Maximum Demand Chart". Tables I, II and III give maximum demand detail figures to support three points on the chart.

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* Pacific Gas & Electric Co., Schedule A-13, Revised P.U.C. Sheet No. 2854-E.