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Cost Equation for 15 Bev Accelerator

Minimum cost of a linear accelerator of fixed energy results when the cost of those items of equipment and services which pertain to accelerator length and those which pertain to radio frequency power are made equal. In addition, there are other items of cost which do not logically belong to either of the above categories but which may be considered as fixed costs for a given installation and for fixed energy. The latter include research facilities and research operating costs (distinct from machine operating costs), site development, general service buildings, miscellaneous equipment items, administratives costs, etc. In comparing costs in the first two categories we note that length-related costs are predominant during the initial construction period while power-related costs are predominant during the operational period. An operating period of 10 years has been used in this analysis as representative of the useful life of the accelerator. If a longer period were used the optimum length of the machine would become longer and the r.f. power requirements would be reduced by a factor proportional to the square root of the designated useful life.

The total cost of the proposed accelerator[1] including construction costs and 10 years operating cost is $255 million (excluding $18 million R. & D. costs). These costs may be divided into 3 categories as follows: (see detailed cost breakdown attached)

Length proportional costs:	$50 million
Power proportional costs:	53
Fixed costs (including research costs)	152
TOTAL	$255

1) Construction costs have been taken from the A.E.C. Construction Project Data Sheets. Operating and research costs have been taken from the original Stanford Proposal but modified so as to total $15 million annually.

The previously mentioned total cost may also be given by the following equation:[2]

$$C = .005\,L + .221\,N + 152$$

where C = cost in millions of dollars
L = accelerator length in feet
N = number of klystrons

From the above equation we have calculated total costs for several combinations of L and N giving the same total energy of 15 Bev. These are given in the following table:

L	N	C
10,000	240	255
5,000	480	283
20,000	120	278.5

We find that L = 10,300 feet and N = 233 klystrons result in minimum costs at 15 Bev energy. Since the cost equation curve is quite flat in the region of minimum cost, there is negligible difference in cost between the L = 10,000 and L = 10,300 feet cases.

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2) This equation is based upon an accelerator length of 10,000 feet and a total of 240 klystrons. The energy is assumed fixed at 15 Bev.

A. Construction Costs

	Item	Length Prop. costs	Power Prop. costs	Fixed Costs
C 1	Improvements to Land			1,956,000
C 2	Buildings			
	General services			154,000
	Klystron Laboratory		592,000	
	Administration			520,000
	Eng. and science			240,000
	Accel. shops & storage	690,000		
	Auditorium			66,000
	Cafeteria			135,000
	Fire Station			10,000
	Guard houses			10,000
	End station			5,600,000
	End station lab. & office			820,000
	Accelerator control			150,000
	D.C. generator			273,000
	Shielding			1,240,000
C 3	Utilities			
	Pacific Gas & Electric lines		144,000	266,000
	Substation & a.c. feeders		1,393,000	2,560,000
	Yard electric work		1,134,000	2,100,000
	Water supply & storage		34,300	63,700
	Cooling water		1,154,000	2,140,000
	Sewers & drains	115,000		115,000
	Air. Cond. in tunnels	385,500	385.500	
	Misc. yard utilities			32,000
C 4	Tunnels	16,764,000		
C 5	Accel. Test section			2,313,000
	Accel. power components		5,007,000	
	Accel. proper	8,457,000		
	Klystrons		1,880,000	

Item	Length Prop. costs	Power Prop. costs	Fixed Costs
Beam switchyard & End Station			861,000
Control & Instr. for Accel.			
Consoles & wiring	365,667	365,667	365,666
R.F. system	529,500	529,500	
Trigger system	95,000	95,000	
Infl. & Defl. system	632,000		
Aux. systems	213,000		
Vac. gauges	594,000		
Comm. & signals	51,000	51,000	
Other controls & Instr.	461,333	461,333	461,334
6 Equipment			
Research equipment			4,098,000
Klystron lab		490,000	
Accel. Fab. equip.	684,000		
Hauling & handling equip.			
End Station, etc.			377,000
Accel. Lab. & shops			21,000
Tunnel transportation	49,000		
Tunnel monorails	102,000		
Trucks, fork lifts			55,000
Tunnel elevator			27,000
Cars			15,000
Furniture, storage & office			470,000
Misc. equip. items			2,712,000
TOTAL CONSTRUCTION COSTS	30,188,000	13,718,300	30,748,700
		Eng., design, Inspection	7,600,000
			38,348,700

Escalation and contingency factor: $\frac{105}{82.25} = 1.278$

Costs after application of escalation and contingency:

Eng., Design and Inspection	$38.5 M	$17.5 M	$49.0 M

B. Operating and Research Costs Over 10 Years

	Length Prop. costs	Power Prop. costs	Fixed Costs
1. Machine Operation & Maintenance			
a. Klystrons		11,500,000	
b. Accelerator operators, Machinists & Brazers, Accelerator Techniciams			13,000,000
c. Power for Kly. Mod.		12,500,000	
d. Other materials & equipment	11,500,000	11,500,000	
2. Research			35,000,000
3. Large Research Equipment			25,000,000
4. Capital Improvements			15,000,000
5. Adm. & General Services			15,000,000
TOTAL 10 yr. Oper. & Res. costs	11,500,000	35,500,000	103,000,000
Plus initial constr. costs	38,500,000	17,500,000	49,000,000
TOTAL COSTS	50,000,000	53,000,000	152,000,000