The season electrical power cost for refrigerating equipment is then given by the following equation:

$$\text{Season power cost} = \frac{0.746\,(\text{bhp}_t)\,T\,H_e\,R}{\eta} \tag{3}$$

where

bhp$_t$ = Brake horsepower per ton (see Fig. 1) for *average* load during period. (Due allowance should be made for poorer compressor efficiency at light load).
T = Tons of refrigeration at maximum design load.
H_e = Equivalent full load refrigeration operating hours (Table 8).
R = Power cost, dollars per kwhr, including demand and energy charges.
η = Motor efficiency at average load (decimal).

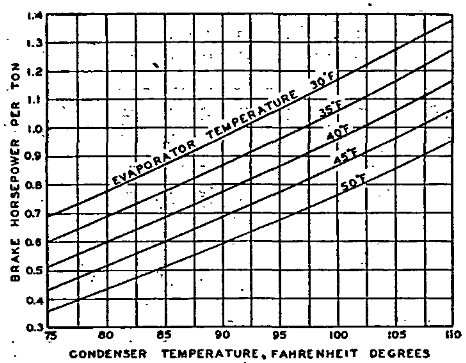

Fig. 1. Typical Brake Horse Power Requirements for Refrigeration[a]

[a]Values given are representative of "F-12" reciprocating machines of about 25 tons capacity in air conditioning applications. Requirements of smaller machines are usually higher, and for larger machines may be lower. Values shown are for liquid refrigerant at condenser temperature (no subcooling). Subcooling of the liquid may decrease these values approximately 0.3 per cent to 0.5 per cent for each Fahrenheit degree the liquid temperature is lowered.

Table 9 will be useful in estimating the design load in the absence of detailed load estimates.

In considering refrigeration power consumption, it should be noted that the use of weather records for a specific year may lead to large inaccuracies in estimating operating costs, since there may be wide variations from year to year, and therefore, average yearly weather records should be used rather than those for any individual year.

If the refrigeration compressor is steam turbine driven, the same general method can be followed, taking into account average water rate per bhp-hr and the cost of steam.

Condenser Water

Condenser water cost estimates can also be based on equivalent full load operating hours of the refrigeration equipment. The varying temperature of the water at its source, as well as the temperature of the discarded water, must however be taken into account. In general, when water is purchased, control is provided to hold the leaving water temperature (or condensing temperature) constant; and in such case the entering water temperature becomes the major variable and the gpm per ton can readily be calculated for any water temperature rise.

The following equation for cost of condenser water is useful:

$$B = 0.060\,a\,T\,H_e\,C \tag{4}$$

where

B = Cost of water for refrigeration during period, dollars.
a = Average gallons per minute (ton).
T = Tons of refrigeration at maximum design load.
H_e = equivalent full load refrigeration operating hours (Table 8).
C = Water cost, dollars per 1000 gal.

The average gpm per ton must take into account the variable water temperature. When well water is used as a source, and entering and leaving temperatures are considered constant, the average gpm per ton obviously is equal to the design gpm per ton. However, when the source is river or lake water, its maximum seasonal temperature will generally be reached at the same time that the refrigeration load factor is highest.

Table 9. Representative Tons per 100 Sq Ft for Various Applications

	Low	Avg	High
Department Store (Main Floor)	0.50	0.58	0.67
Department Store (Upper Floors)	0.29	0.46	0.54
Dress Shop	0.29	0.50	0.71
Drug Store	0.33	0.54	0.83
Lunch Room	0.83	1.08	1.33
Office Bldg.	0.21	0.25	0.38
Restaurant	0.58	0.75	1.00
Shoe Shop	0.29	0.42	0.63
Theater (Tons per Seat)	0.064	0.078	0.093

The average gpm per ton should be calculated from known or estimated water temperatures because they vary through the season. Maximum water main temperatures are given in Chapter 37 but should always be verified locally. In lieu of this tedious work, the average gpm per ton may be taken as 80 per cent of design gpm per ton with reasonable accuracy, for the condition of variable temperature of entering water obtained from rivers and lakes.

When cooling towers or evaporative condensers are used, the windage and evaporation losses are usually between 3 per cent and 5 per cent of the water circulated.

Heating

The method of estimating fuel consumption to balance the building heat loss is given in Chapter 20. It is important to include the fuel required to heat ventilation air as used in ventilating and air conditioning systems. In estimating fuel consumption for ventilation air, the tendency of the conventional control systems to use less than the estimated quantity of outside air in cold weather should be considered in its effect in lowering fuel consumption. In addition, the heat required to accomplish winter humidifying must not be neglected, when this feature is included in the equipment.

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