Common Unit Conversions

1 kW = 3,412 Btu/h

1 ton = 12,000 Btu/h

1 MMBtu = 1,000,000 Btu = 10 Therms
1 Therm = 100,000 Btu
1 MBH = 1 kBtu/h = 1,000 Btu/h
1 Boiler hp = 33,475 Btu/h

1 psi = 2.31 ft of head = 2.036 in Hg
P_{Abs} (psia) = P_{Gauge} (psig) + P_{Atm}, where P_{Atm} = 14.7psi

1 hp = .746 kW = 2,545 Btu/h
*if calculating heat gain from motors, divide by efficiency

°C = 5/9 * (°F-32) °F = 9/5 * °C + 32 °R = °F + 460
°K = (°F + 460) * 5/9 = °C +273

Common Formulas

kW = Volts * Amps * PF * 1.73 / 1,000 (for 3 phase power)

kW of Motor Load = .746 * hp * Load Factor / Motor Efficiency

Airside Sensible Cooling Load (tons) = 1.08 * cfm * ΔT / 12,000

Waterside Cooling Load (tons) = 500 * gpm * ΔT / 12,000

Airside Heating Load (Btu/h) = 1.08 * cfm * ΔT

Waterside Heating Load (Btu/h) = 500 * gpm * ΔT

kW/ton = 12 / EER

EER = Cooling COP * 3.412

COP = Work Done / Energy In

Pump hp = Ft Head * gpm * SG / 3960 / Pump Eff (SG water = 1)

Fan hp = Static Press * cfm / 6354 / Fan Eff

Motor kW (when shaft power is known) = Shaft hp * .746 / Motor Eff

Conductive Heat Transfer (Btu/hr) = U * A * ΔT, where U=1/R and A is in ft^2
Solar Heat Gain = SHGF * A, where SHGF = Solar Heat Gain Factor

Affinity Laws (P=Power, H=Head/Pressure, Q = flow)
$Q_1/Q_2 = RPM_1/RPM_2$ $H_1/H_2 = (RPM_1/RPM_2)^2$ $P_1/P_2 = (RPM_1/RPM_2)^3$
*Actual exponents are lower than formulas

Common Rules of Thumb

Water Cooled Chiller Efficiency = .5 - .8 kW/ton

Chilled Water Flow = 2.4 gpm/ton

Condenser Water Flow = 3.0 gpm/ton

DX/Air cooled chiller efficiency = 1-1.3 kW/ton

AHU Airflow = 400 cfm/ton

Lighting Power Density = .75 to 1.5 watts/sf (office and similar)

Equivalent Full Load Hours (EFLH) = 350 – 600 hrs for non-process cooling in PNW.

CW Reset = A decrease in condenser water temp will save between .75% and 1.5% per deg at the chiller. Constant speed chillers are closer to .75%, VFD closer to 1.5%. The same applies to refrigerant temperature in a refrigeration system.

CHW Reset (Const Speed Chiller) = An increase in chilled water temperature will save approximately .75% per deg at the chiller.

CHW Reset (VFD Chiller) = An increase in chilled water temperature will save approximately 2% per deg at the chiller. Note that if the coils have two way valves, this could increase pump power.

Suction Temperature Reset = An increase in refrigerant suction temperature will save approximately 2% in compressor power per degree.

EUI = A typical existing commercial building in the PNW may be in the range of 75-125 kBtu/sqft. New construction will be closer to 50-60 kBtu/sqft.