# Process Cooling System *Cheat Sheet*

Top 5 Energy Conservation Measures

1. Convert chilled water systems from constant to variable flow by replacing 3-way with 2-way control valves and installing VFD on distribution pumps

2. Convert condensing water systems from constant to variable flow by installing VFD on condensing water pumps

3. Convert cooling tower fan from 1-speed or 2-speed to variable speed by installing VFD

4. Reset chilled water supply temperature setpoints based on process load

5. Reset condensing water entering temperature setpoints based on ambient wet bulb temperature

Process Cooling Systems' Cost Comparison
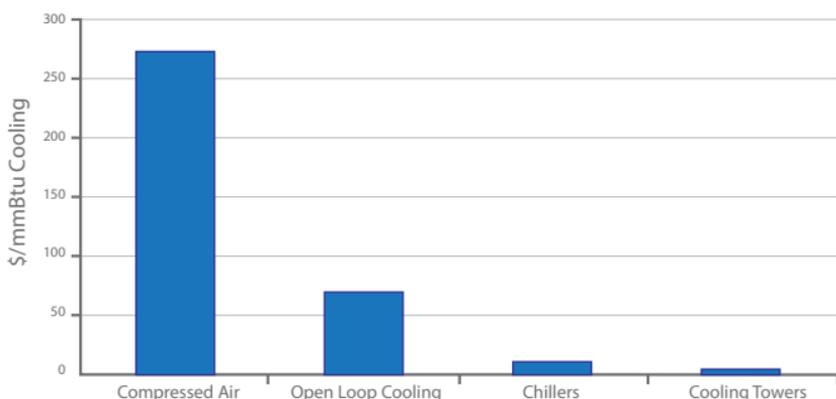
Water Cooled Chiller Comparison

Chiller Type	Capacity [1] Range (tons)	First Cost [2] Range ($/ ton)	COP Range	IPLV Range (COP)
Reciprocating/ Scroll	50–230 (400)	$200–$250	4.2–5.5	4.6–5.8
Screw	70–400 (1250)	$225–275	4.9–5.8	5.4–6.1
Centrifugal	200–2000 (10,000)	$180–$300	5.8–7.1	6.5–7.9
Single-effect Absorption	100–1700	$300–$450	0.60–0.70	0.63–0.77
Double-effect Absorption	100–1700	$300–$550	0.92–1.20	1.04–1.30
Engine Driven	100–3000 (10,000)	$450–$600	1.5–1.9	1.8–2.3

[1]Capabilities in parentheses are maximun sizes available

[2] First cost includes allowance for contractor mark-ups

Courtesy of Energy Design Resources

betterbuildingssolutioncenter.energy.gov

Process Cooling System *Cheat Sheet*

Rules of Thumb

1. 1°F increase of chilled water temperature improves the chiller efficiency by approximately 1.5%; 1°F decrease of condensing water temperature improves the chiller efficiency by approximately 1.5%
2. Pump sizing: 2.0 – 2.4 GPM/ton for chilled water and 2.5 – 3.0 GPM/ton for condensing water
3. Distribution pipe sizing: 10 ft/s water velocity or 4 ft w.c. pressure loss per 100 ft

Unit Conversion

1. kW/ton = 12/EER; EER = COP × 3.413; kW/ton = 12/(COP × 3.413)
2. 1 refrigeration ton = 12,000 Btu/hr; 1 cooling tower ton = 15,000 Btu/h
3. 1 HP =745.7 W; 1 ft w.c. = 0.433 psi
4. C = (F − 32) × (5/9)

Integrated Partial Load Value (IPLV) Equation

$$IPLV = \cfrac{1}{\cfrac{1\%}{A} + \cfrac{42\%}{B} + \cfrac{45\%}{C} + \cfrac{12\%}{D}}$$

Where: A = kW/ton @ 100% load
B = kW/ton @ 75% load
C = kW/ton @ 50% load
D = kW/ton @ 25% load

Cooling Tower Water Consumption

Cooling Tower Usage (Million Gallons/Year)

Chiller Tonnage	Cycles of Concentration			
	3	5	7	8
100	2.0	1.7	1.6	1.5
200	4.0	3.4	3.1	3.1
400	8.0	6.7	6.3	6.1
600	12.1	10.0	9.4	9.2
800	16.1	13.4	12.5	12.3
1000	20.1	16.8	15.6	15.3
2000	40.2	33.5	31.2	30.6
3000	60.3	50.3	46.9	46.0
4000	80.4	67.0	62.6	61.3
5000	100.5	83.8	78.2	76.6

Resources

1. ASHRAE Handbook: HVAC Systems and Equipment by ASHRAE
2. Chilled Water Plant Design Guide by Energy Design Resources

betterbuildingssolutioncenter.energy.gov