The Evolution and Evaluation of Cooling Towers:

Successfully navigating today's challenges

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Historical 80/20 Evaluation Criteria

- **Installed fan HP**
- **Footprint**
- **Lowest cost**

Today's Challenges

- **Airborne dirt and sand**
- **Alternate water sources and water conservati**
- **Larger rooftop applications**
- **Corrosive environment**
- **Legionnaires' Disease**
- **Rapidly growing and changing demand**
- **Overall system energy conservation**
- **Lowest total installed cost possible**

Airborne Dirt and Sand

- **Decreased effectiveness of water treatment**
- **Reduced condenser tube life**
- **Increased maintenance**
- **Less thermal performance**

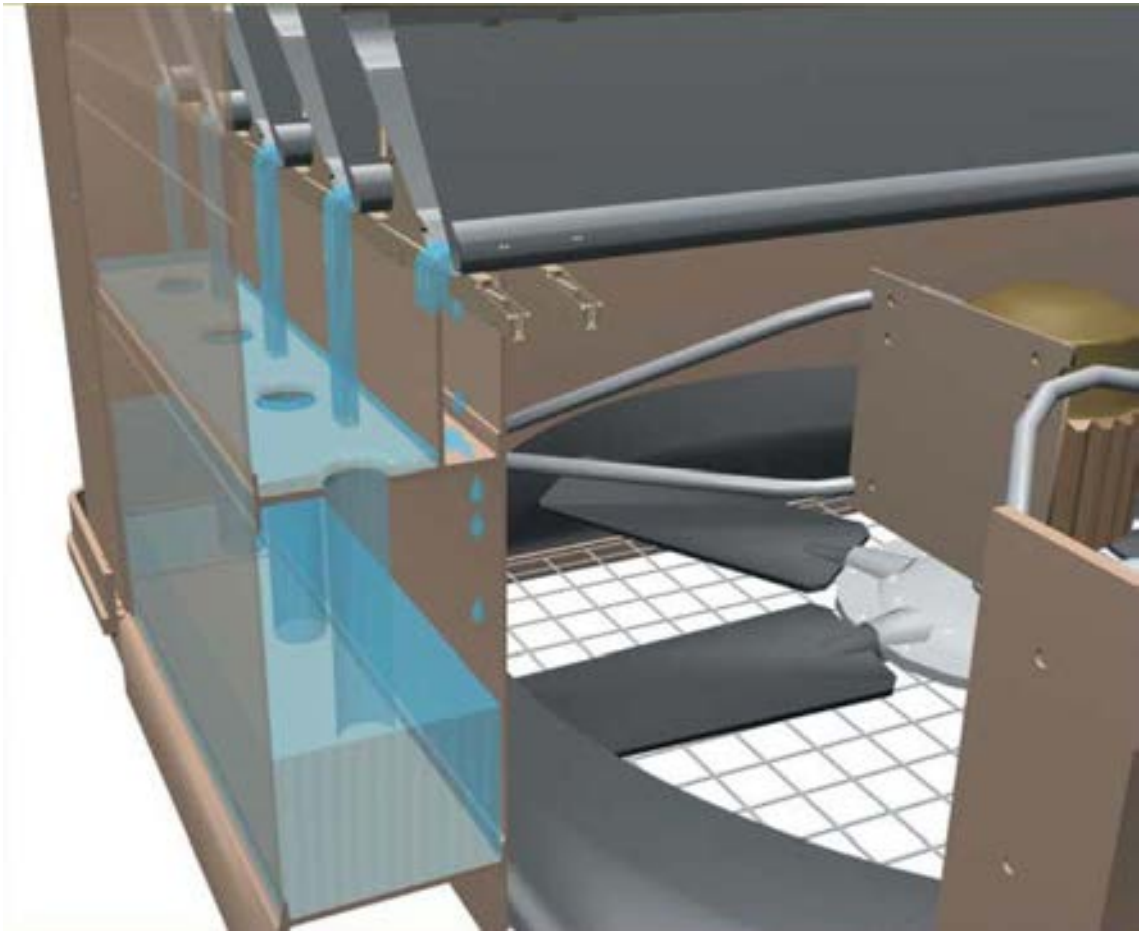
Conventional Approach

Deal with it after ingested

- **More frequent cleaning**
- **Basin sweeper system**
- **Larger filtration system**

New Tech Approach

Water Collection System



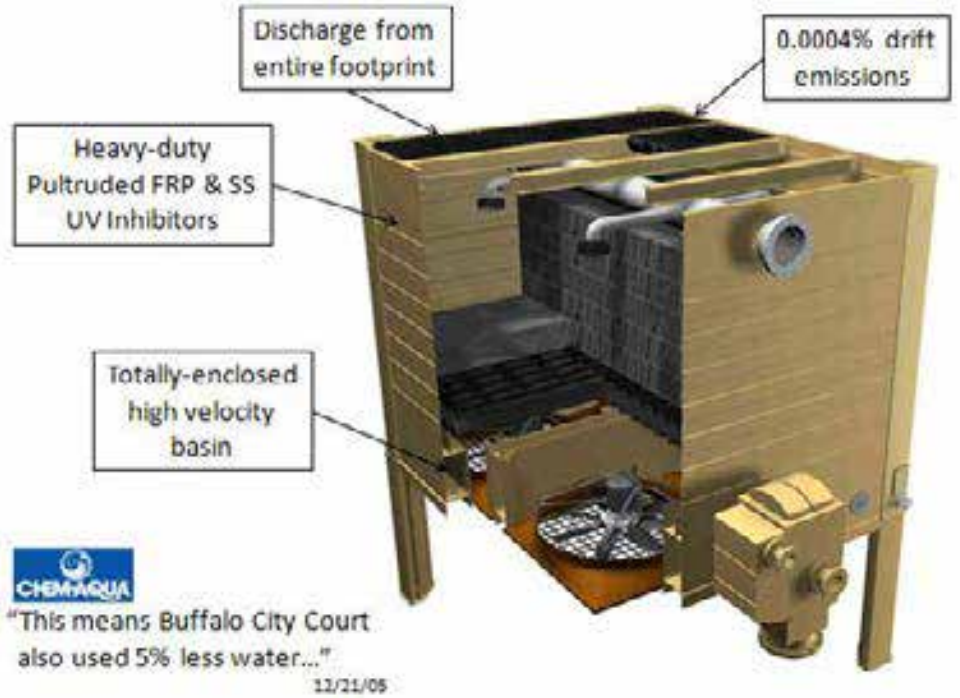
Bottom Mounted Fan System

Water Conservation

- **Executive Order No. 27 in Dubai**
  - **Sea water or TSE for all new District Cooling plants**
- **10,000 TR average load**
  - **200 million US gallons or 750,000 M³ of water annual consumption**

Conventional Approach

- **Non-corrosive materials**
- **0.002% drift emissions**
- **Water softeners (+10% waste)**
- **Basin sweepers**
- **Filtration & Separators**

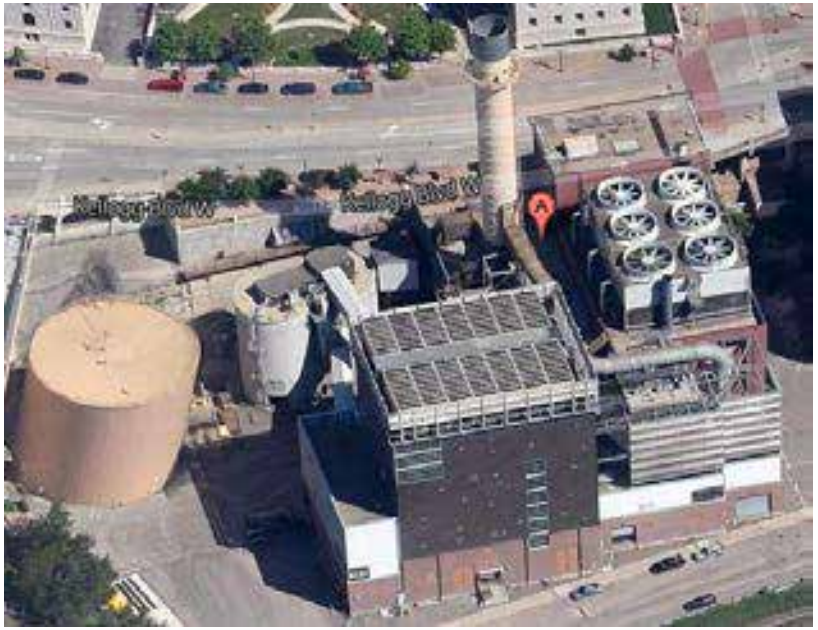


Variable Flow Technology

- Variable flow orifice ensures optimum coverage of fill surface area during part-load operation.
- Coverage of fill surface with an improved spray pattern results in lower operating cost and reduced maintenance – Square not Round.
- Spreading the water volume over more fill improves the KaV/L and reduces evaporation

Large Rooftop Applications

- **Costs**
  - **Building footprint**
  - **Cooling Tower**
  - **Installation**
  - **Civil work**



Conventional Approach

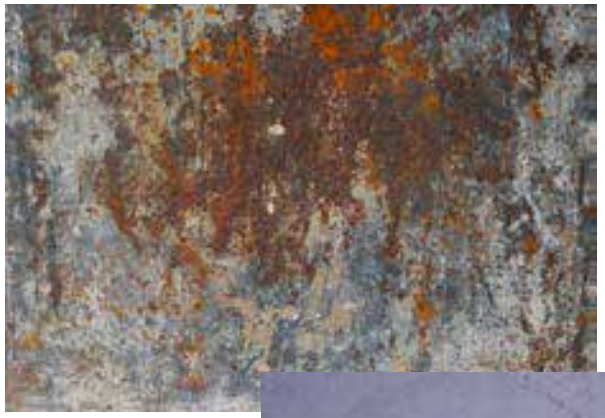
- **Cheapest “cooling tower” cost**
- **Smallest footprint possible**
- **Fewest cells possible**

Tower Tech Approach

- **Arrives fully assembled**
- **50% less weight and height**
- **Bottom vs. side air inlets**

Corrosive Environment

- **Sunny, hot, humid, sea air**
- **Gritty and/or TSE water with chemical**

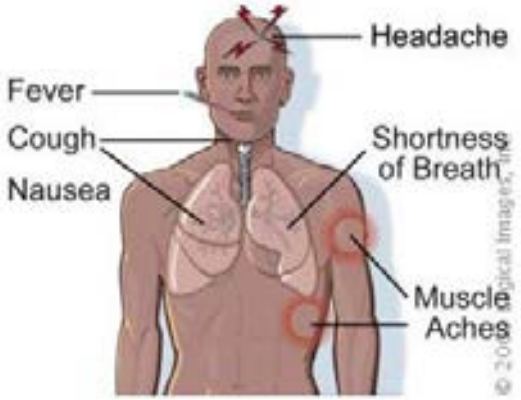


Common Approach

- **Pultruded FRP with SS hardware**

Legionella

- **Grows in cooling tower basins**
- **Transmitted from drift emissions**
- **Host breathes it in**



<u>Conventional Approach</u>

- **Thorough cleaning at least quarterly**
- **Basin sweeper system**
- **Filtration system**
- **0.001-0.002% drift rate**

<u>New Techology Approach</u>

- **Annual cleaning**
- **High velocity, self cleaning basin**
- **Filtration system**
- **0.0004% drift rate**

Legionnaires' Disease

Quebec City public health officials say they've found the likely source of the outbreak of legionnaires' disease that has killed 13 people and made nearly 170 others ill since July.

Posted Fri 23 Aug 2013, 11:42am AEST

Queensland Health says it will have to set up a permanent disinfection system at three hospitals in the state's south-west to prevent recurring outbreaks of legionella.

Legionnaires disease outbreak in Ohio retirement community causes infections and deaths

Since June 1, there has been a larger legionella cluster within Milwaukee County representing 48 total cases, with 31 in the City

The currently accepted theory is that multiple cooling towers in and around downtown Milwaukee are the source of the legionella bacteria, according to Rausch.

Neshannock Township business closed after bacteria found in water cooling tower

Posted: Aug 18, 2013 1:19 PM CST

Cooling tower contamination leading to Legionnaires' disease outbreaks

AUGUST 8, 2013 6:07 AM 0 COMMENTS AUTHOR: IAN ANDREW

A further case of Legionnaires' disease linked to the Renfrew area has been confirmed, bringing the total to 11.

Published: Wednesday, July 31, 2013, 12:01 a.m.
Updated: Friday, August 2, 2013

Officials at the state prison in Somerset have traced the illnesses of four inmates to Legionella, a potentially dangerous bacteria found in the facility's cooling tower, state Department of Corrections officials said Tuesday.

Jul 29, 2013 | Vote 0 0

Peel Health sees jump in legionnaires' disease

Hagerstown inmate tests positive for Legionnaires' disease

No other cases known to state officials as they test facility's water, air-conditioning systems

August 16, 2013 | By Scott Dance, The Baltimore Sun

Evolving Demand

- **New plants built based on anticipated demand**
- **Operate at partial capacity**
- **Uncertain future demand and timing**

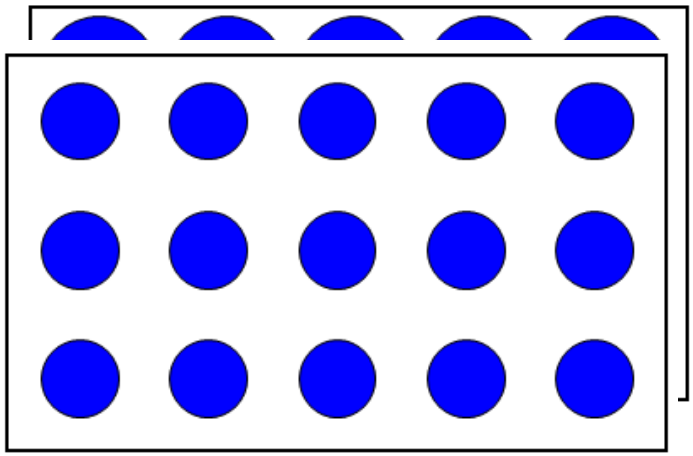
Conventional Approach

- **Packaged galvanized towers**
- **Build out full tower and/or civil now**

New Tech Approach

Overall System Efficiency

- **Total installed fan HP**
- **Minimum fan motor frequency allowed with VFD**
- **Pump head**
- **Variable-flow turndown capability while efficiently covering all fill media within the cell**



Warning: Maintain at least 85% pressure for proper distribution

Efficiency Comparison

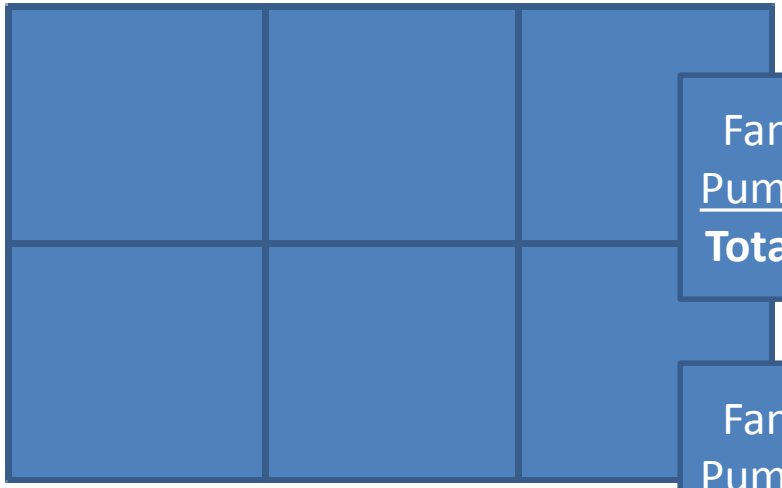
- **30,000 TR system operating range example**
  - **90,000 GPM - 105°F HWT / 95°F CWT / 87°F WBT**
  - **6 x 5,000 TR chillers**
  - **5,000 TR to 30,000 TR operating range; Equal time at each 5,000 TR increment**
- **Comparison**
  - **Most efficient fixed orifice tower**
    - **6 x 5,000 TR cells**
    - **110 kW/cell = 660 kW total**
    - **Minimum VFD frequency = 25 Hz**
    - **33’ pump head**
  - **Variable flow Tower Tech design**
    - **30 x 1,000 TR cells**
    - **29 kW/cell = 870 kW total**
    - **Minimum VFD frequency = 6 Hz**
    - **13’ pump head**

$$\text{Pump HP} = \frac{\text{Q (Flow)} * \text{HD (Feet)}}{3960 * \text{Pump Efficiency (85\%)}}$$

$$\text{kW} = \_\_\_ \text{ HP} * 0.745699872$$

30,000 TR Operation

90,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

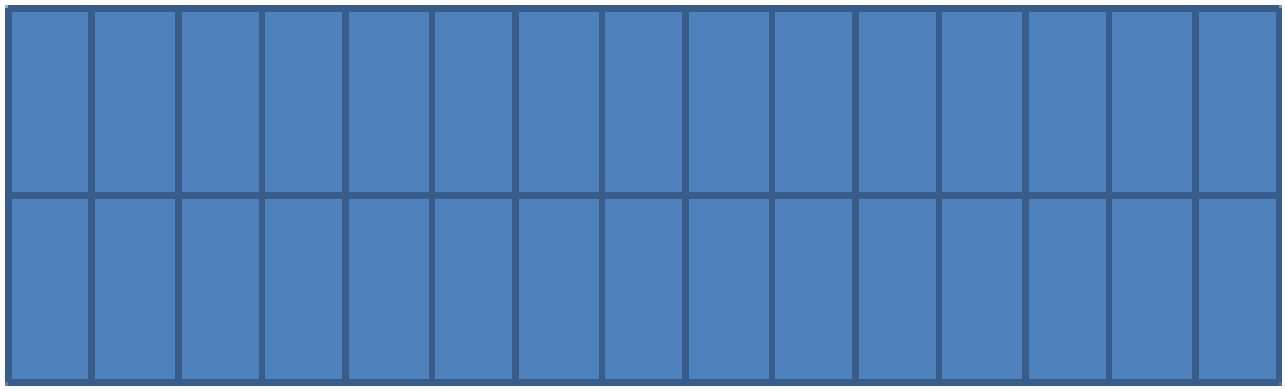


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
-Fan kW = 660
-Pump kW = 649
-Total kW = 1,309

Fan kW/Ton = .029
Pump kW/Ton = .008
Total kW/Ton = .038

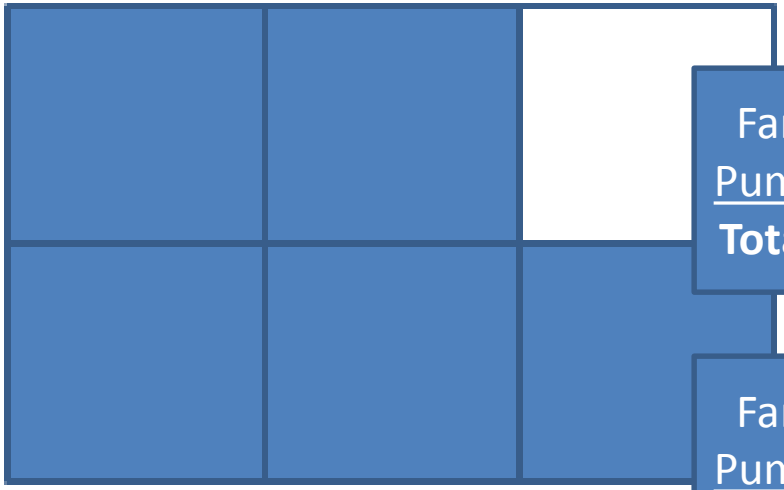
Variable Flow Nozzles
-Fan kW = 870
-Pump kW = 256
-Total kW = 1,126



14% Savings

25,000 TR Operation

75,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

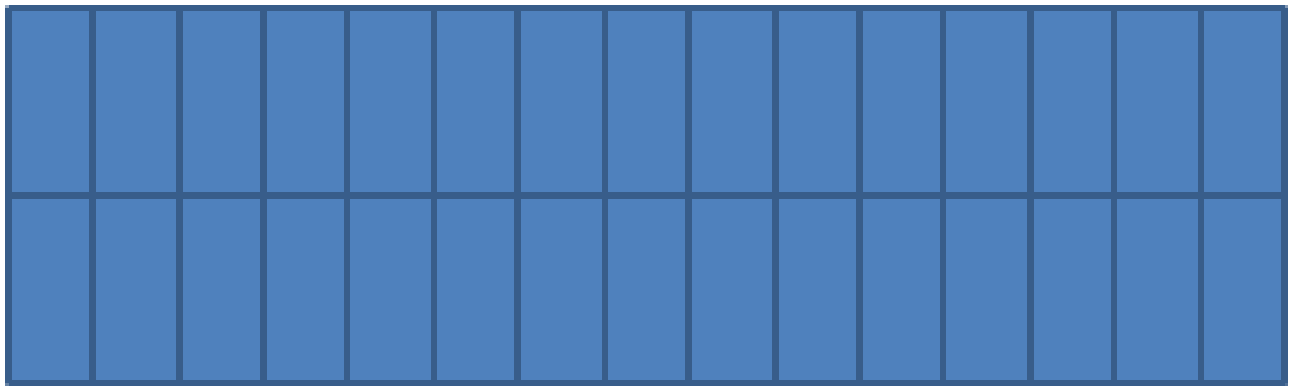


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
- Fan kW = 550
- Pump kW = 541
- Total kW = 1,091

Fan kW/Ton = .017
Pump kW/Ton = .009
Total kW/Ton = .025

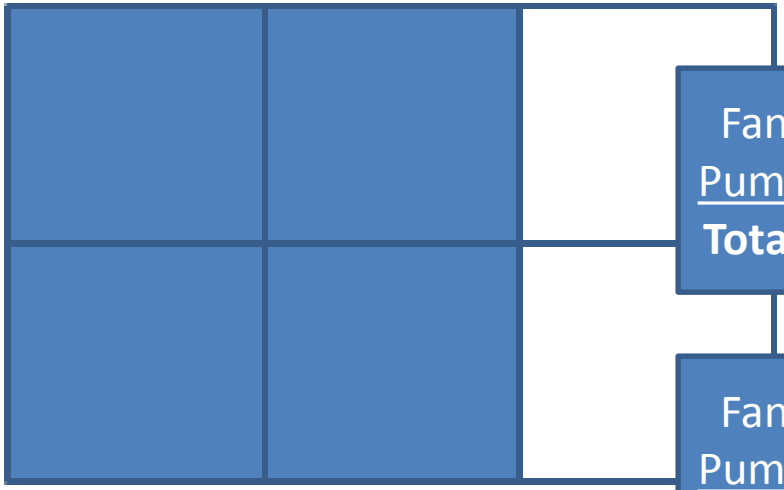
Variable Flow Nozzles
- Fan kW = 420
- Pump kW = 213
- Total kW = 633



42% Savings

20,000 TR Operation

60,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

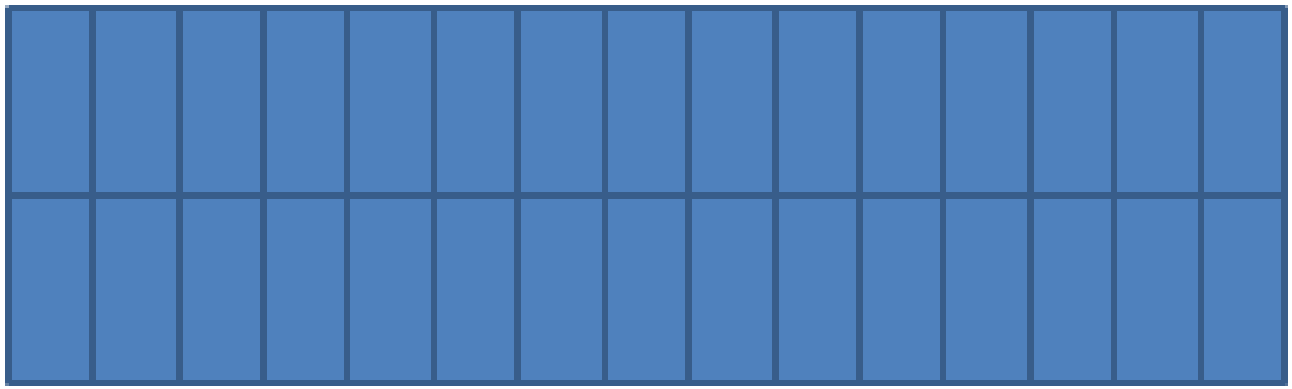


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
- Fan kW = 440
- Pump kW = 432
- Total kW = 872

Fan kW/Ton = .009
Pump kW/Ton = .009
Total kW/Ton = .018

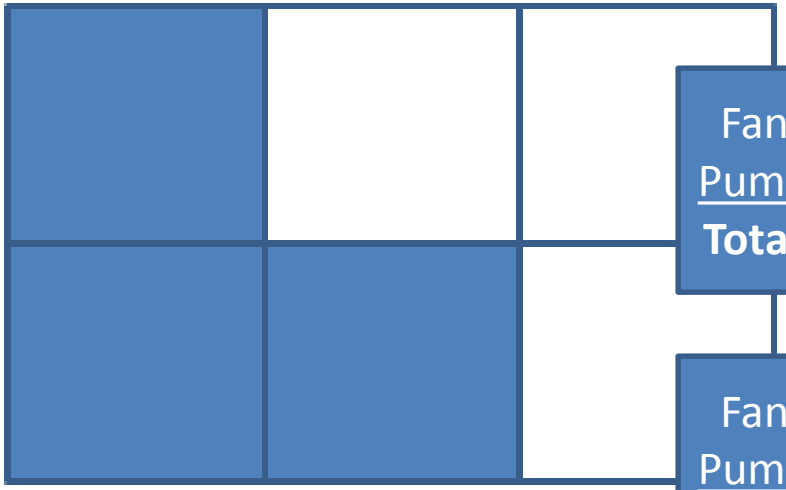
Variable Flow Nozzles
- Fan kW = 180
- Pump kW = 171
- Total kW = 351



60% Savings

15,000 TR Operation

45,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

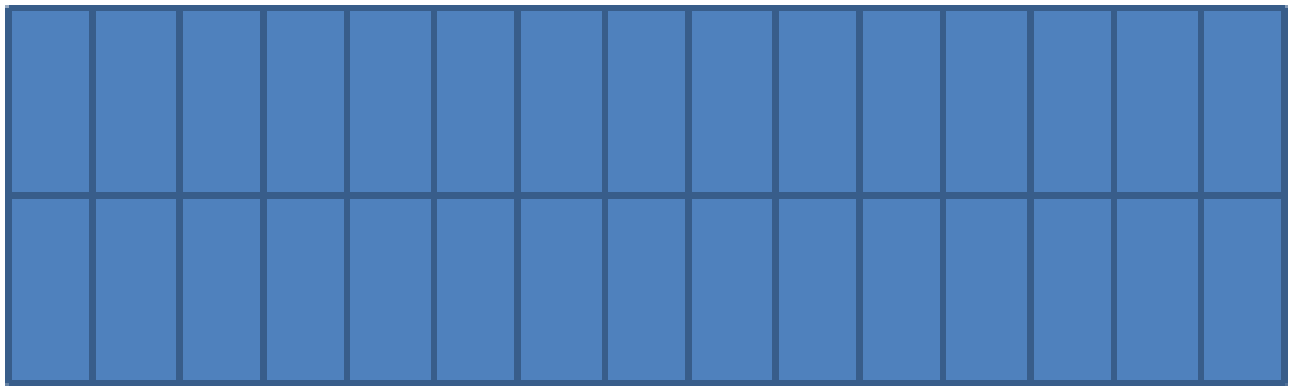


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
- Fan kW = 330
- Pump kW = 324
- Total kW = 654

Fan kW/Ton = .006
Pump kW/Ton = .009
Total kW/Ton = .015

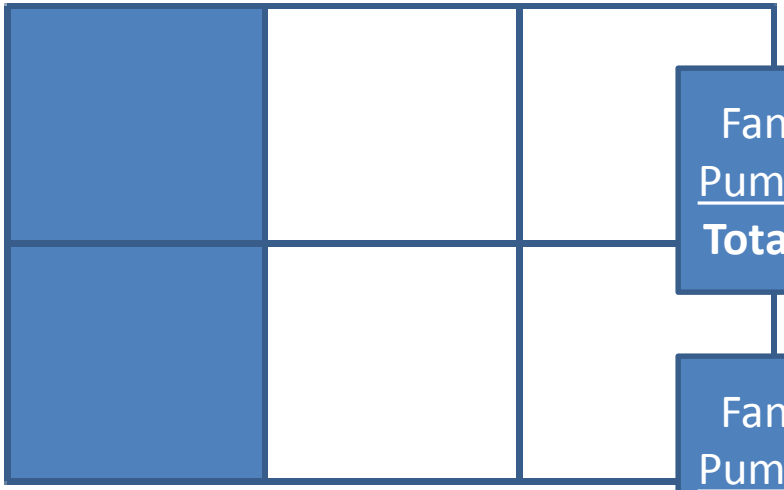
Variable Flow Nozzles
- Fan kW = 87
- Pump kW = 128
- Total kW = 215



67% Savings

10,000 TR Operation

30,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

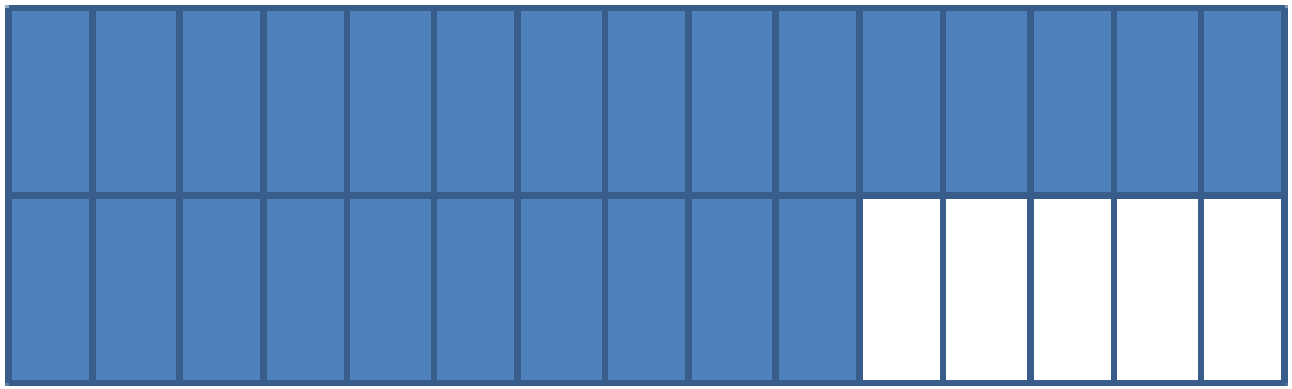


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
- Fan kW = 220
- Pump kW = 216
- Total kW = 436

Fan kW/Ton = .007
Pump kW/Ton = .009
Total kW/Ton = .016

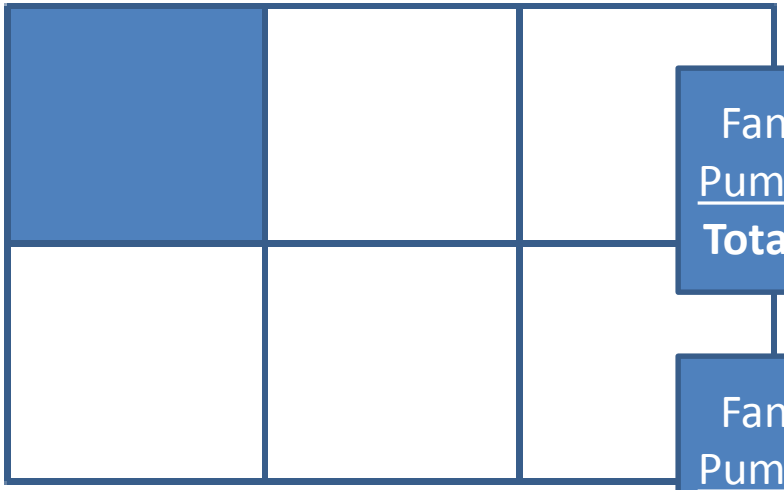
Variable Flow Nozzles
- Fan kW = 73
- Pump kW = 85
- Total kW = 158



64% Savings

5,000 TR Operation

15,000 GPM / 105°F HWT / 95°F CWT / 87°F WBT

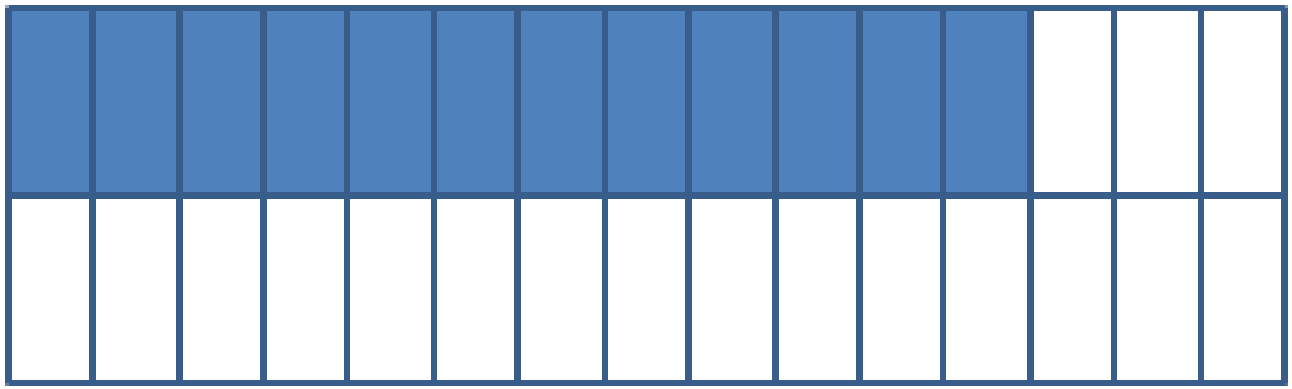


Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
-Fan kW = 110
-Pump kW = 108
- Total kW = 218

Fan kW/Ton = .007
Pump kW/Ton = .009
Total kW/Ton = .016

Variable Flow Nozzles
-Fan kW = 35
-Pump kW = 43
- Total kW = 78



64% Savings

Total Energy Consumed

Fixed Orifice Nozzles @ 33' Pump Head

Tonnage	Hours	kW	Total kW Hours
30,000	1460	1309	1911140
25,000	1460	1091	1592860
20,000	1460	872	1273120
15,000	1460	654	954840
10,000	1460	436	636560
5,000	1460	218	318280
	8760	**4580**	**6,686,800**

Variable Flow Nozzles @ 13' Pump Head

Tonnage	Hours	kW	Total kW Hours
30,000	1460	1126	1643960
25,000	1460	633	924180
20,000	1460	351	512460
15,000	1460	215	313900
10,000	1460	158	230680
5,000	1460	78	113880
	8760	**2561**	**3,739,060**

Fan kW/Ton = .022
Pump kW/Ton = .022
Total kW/Ton = .044

Fixed Orifice Nozzles
-Fan kW = 2,310
-Pump kW = 2,270
- **Total kW = 4,580**

SAVINGS
-Fan kW = 28%
-Pump kW = 61%
- **Total kW = 44%**

Variable Flow Nozzles
-Fan kW = 1,665
-Pump kW = 896
- **Total kW = 2,561**

Fan kW/Ton = .016
Pump kW/Ton = .009
Total kW/Ton = .025

Water Savings

- **Annual Tower Tech Makeup 240.147 Mil US Gal** or **909,564 M³**
- **Annual Conventional Makeup 321.345 Mil US Gal** or **1,217,216 M³**
- **Total Water Savings with Tower Tech 81.198 Mil Gal** or **307,568 M³**
- **25.27% Savings**

Today's Evaluation Criteria

- **Basin sweeper system or High-Speed-Flow-Thru-Basin**
  - Minimize sand/dirt build up; Improved chiller life/performance; Legionella risk mitigation; Improved chemical treatment effectiveness
- **Heavy-duty non-corrosive construction**
  - Flexibility with alternate water sources; Life expectancy; ¼" or thicker pultruded FRP with SS metal
- **Total initial cost**
  - True comparison of actual cost; Building cost with footprint required differential + cooling tower cost + civil work for tower + parapet wall + tower installation cost
- **Add operating cost for best ROI**
  - Ensure best return on investment for ownership; Total installed cost + [water + chemical + maintenance + energy * X years] = Total evaluated cost

Additional Project Specific Consideration

- **Lowest possible drift emissions**
  - Water conservation; Legionella risk mitigation
- **Modularity consideration**
  - Flexibility for evolving demand

New Technology Summary

- Less maintenance and reduced down time
- Able to handle any water source while conserving water
- Longer serviceable life
- Exceptionally low risk for Legionella and bio growth
- Easy to match cooling needs with evolving demand
- Most energy efficient system for lowest operating cost
- Total installed cost minimized due to smart evaluation
- Best return on investment