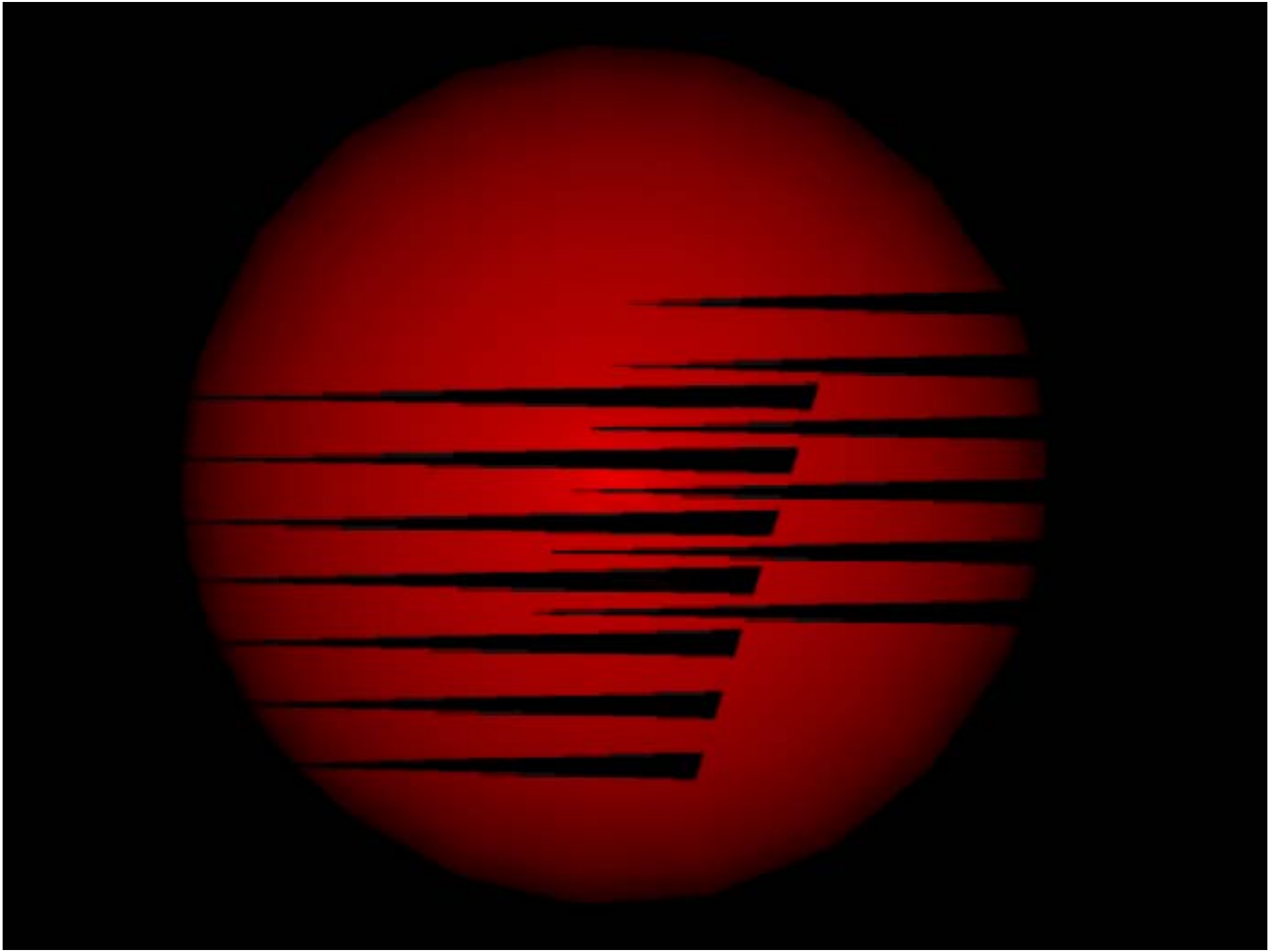

Beyond the Flanges, A Look at Chilled Water System Design

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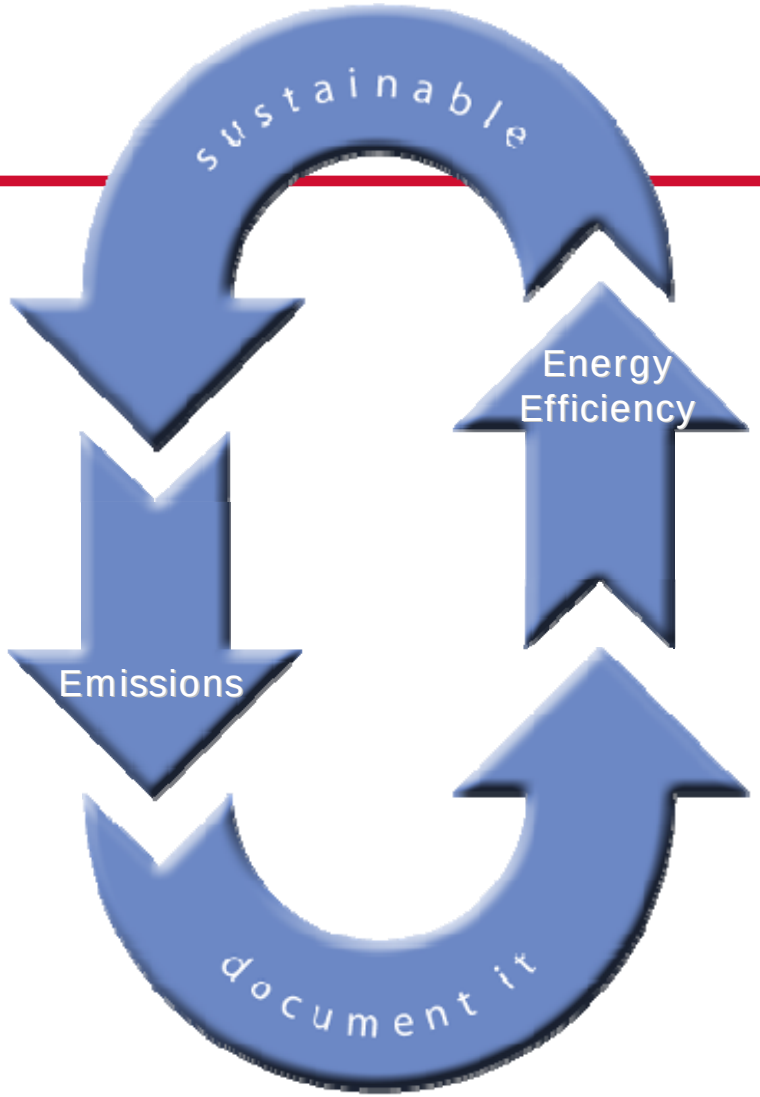
Reduce Environmental Impact through

- Energy Savings through Design
- Control to Optimum Energy
- Continuous Validation for Sustainability

EarthWise™ Systems



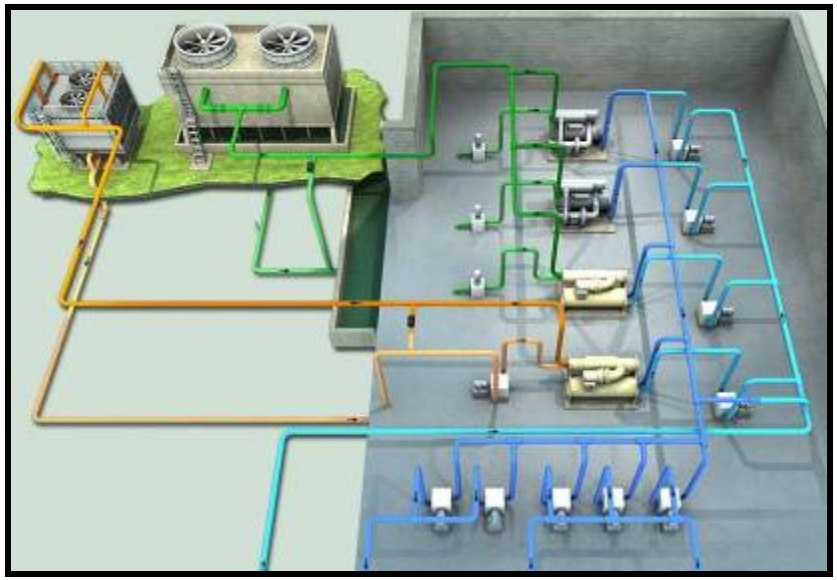
Service/Parts/ Solutions

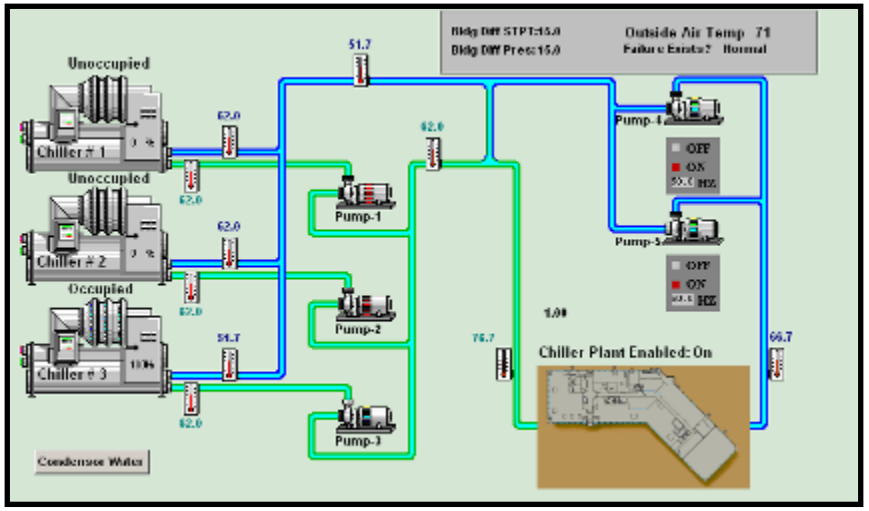
Products

Controls

First Cost

Energy Consumption

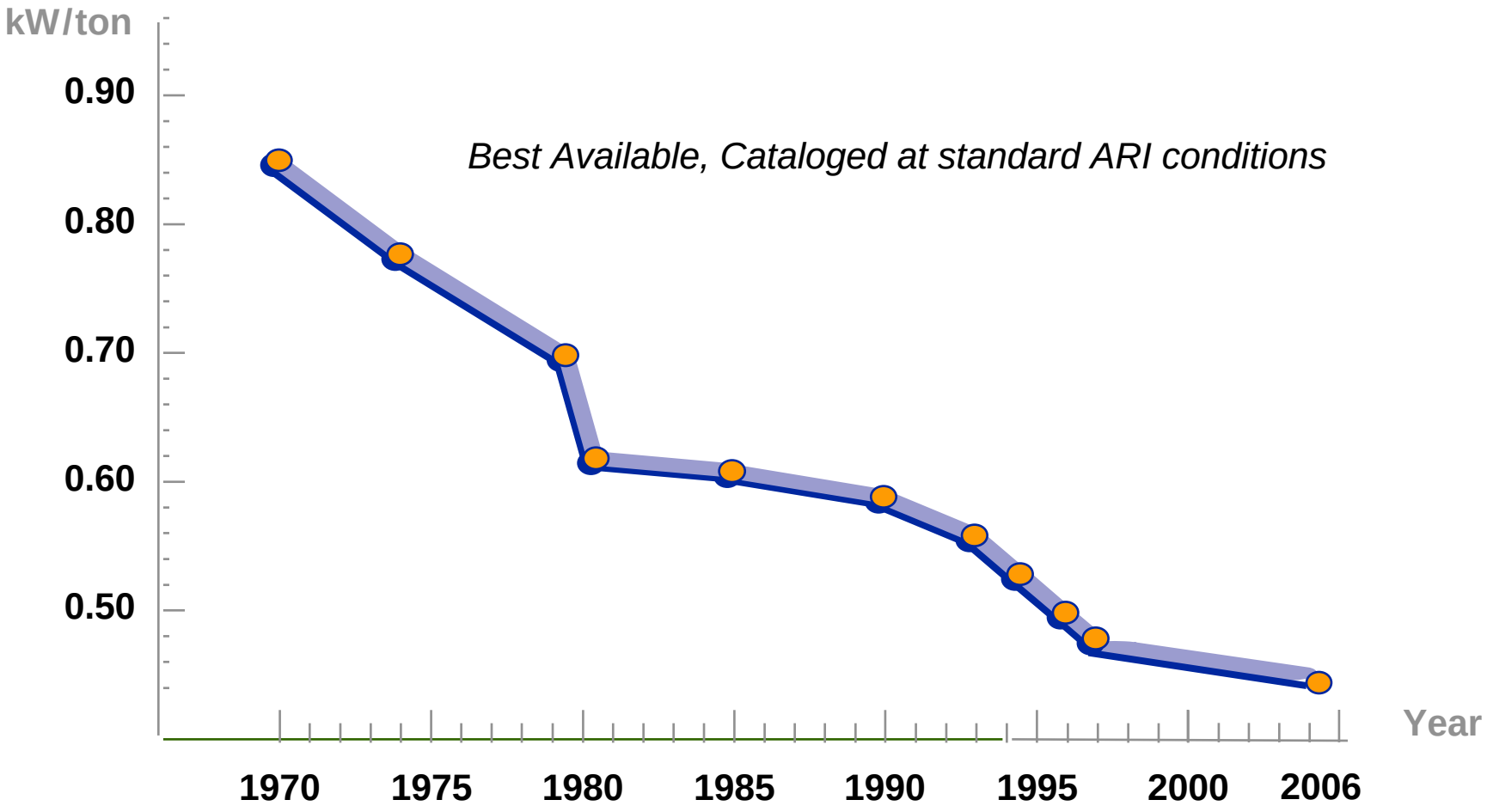




Typical Water Cooled Chilled Water System

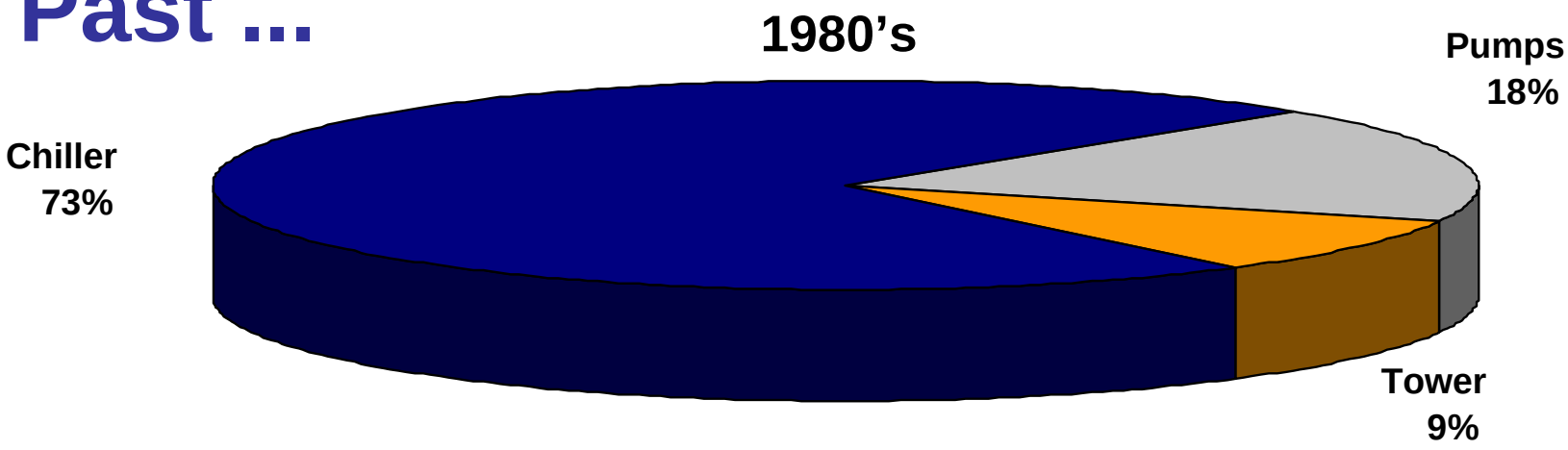
How???

Chiller technology improvements!

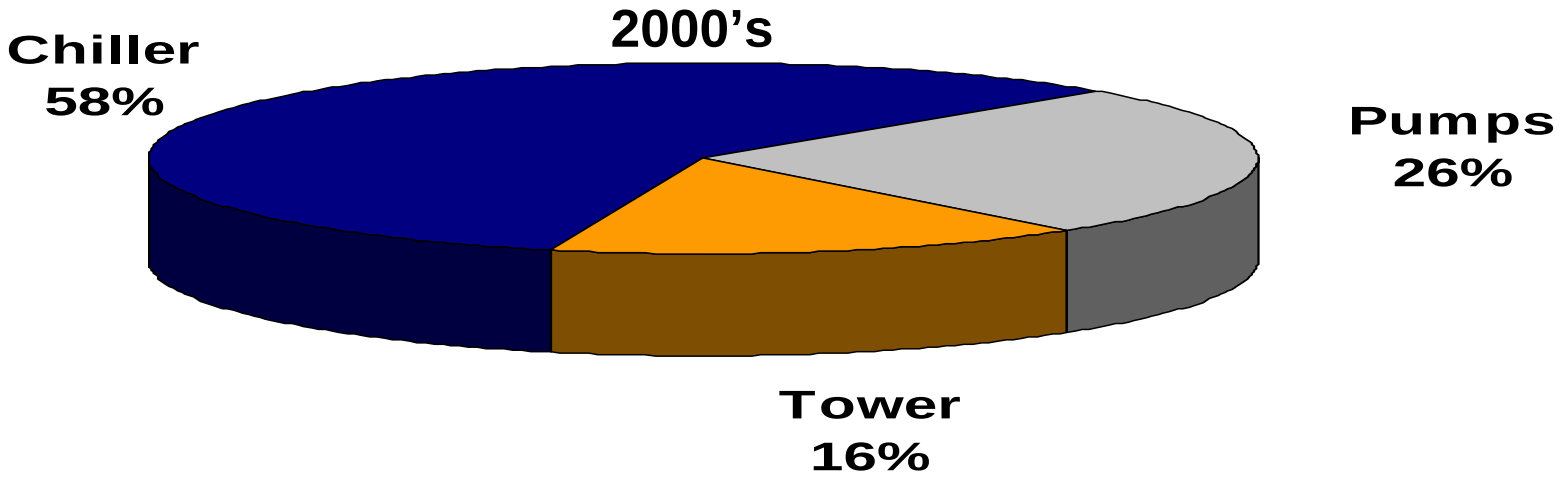


Annual Energy Cost
Conventional Chilled Water System

Past ...

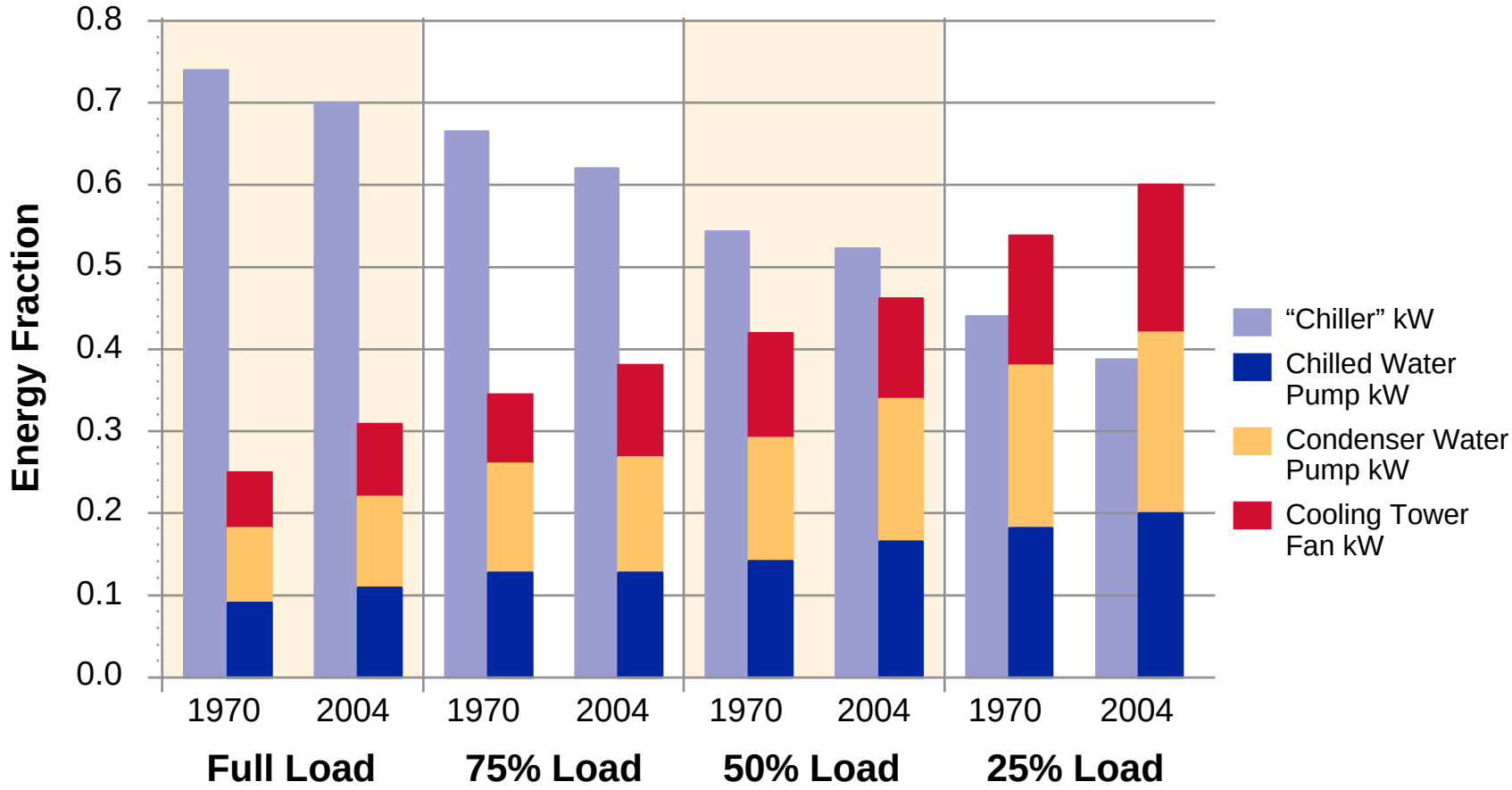


Present ...



a comparative "energy sensitivity" analysis …

Ancillary Equipment Impact

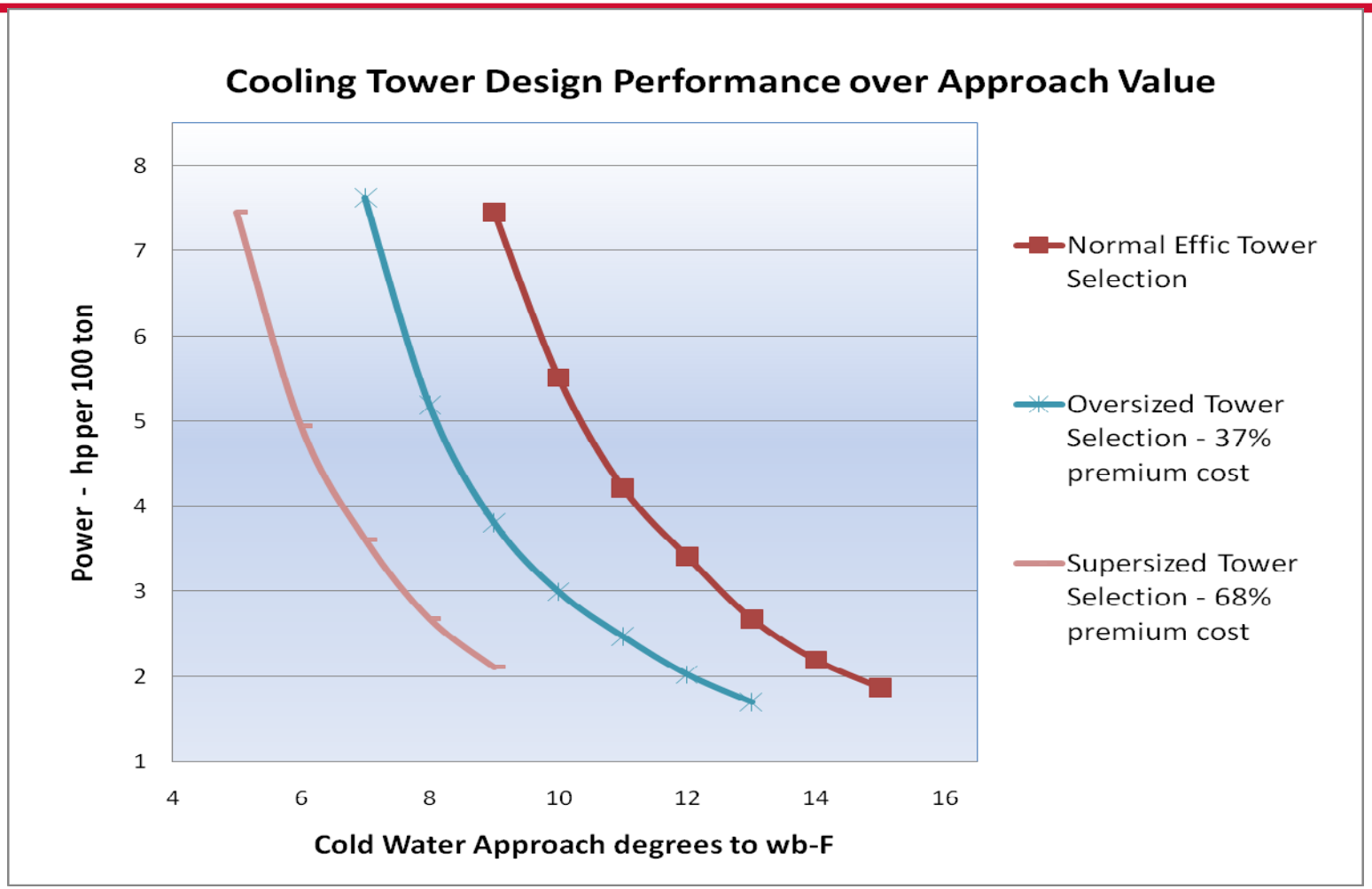


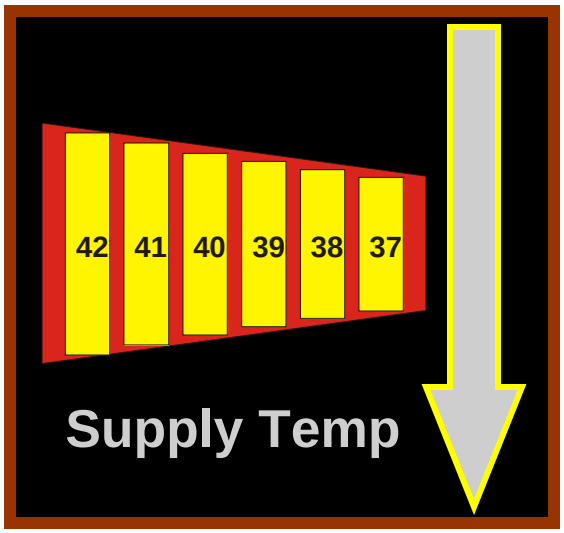
Cooling Tower Performance

"!Tower water should be hot!" ***1st***

Towers fans should use VFDs! ***2nd***

Cooling Tower Selection



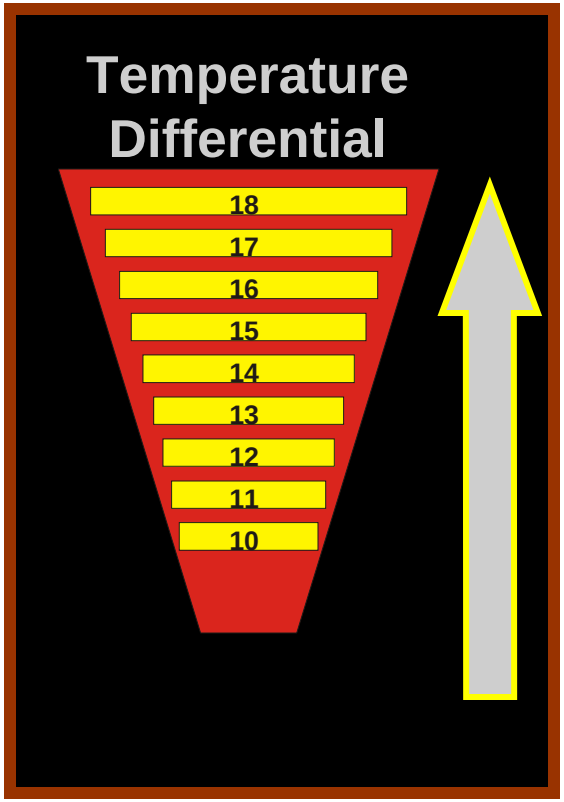


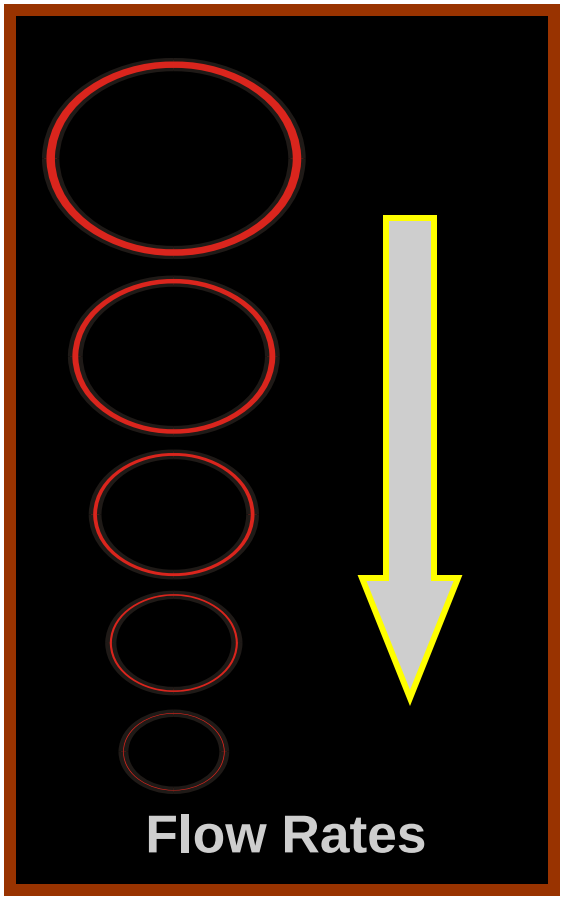
Mass (capacity) varies directly with flow

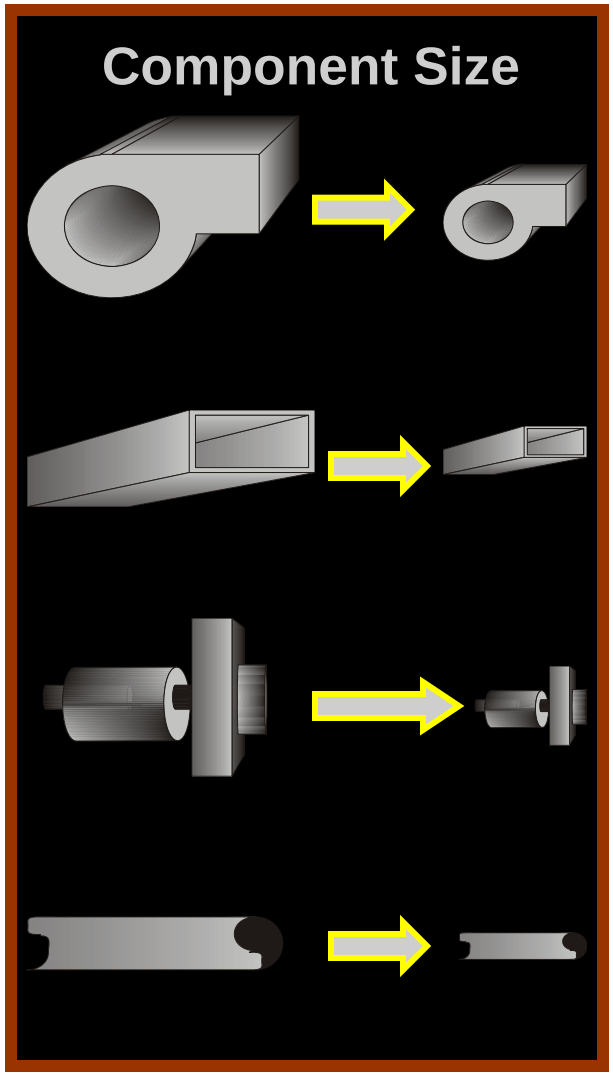
Pressure Drop varies with ~square of the flow

Energy Consumption varies with ~cube of the flow

Based on $Q = \dot{m} \Delta T$







Low Flow Chilled Water Plant Design …

A Paradigm Shift - New "Rules of Thumb"

- **New "rules of thumb"**
  - ~~44°~~ ⇨ **Lower chilled water supply (such as 41° F)**
    - ***Or colder, down to 34 degree water for large plants***
  - **Larger ΔT across evaporator (such as 16° F)**
    - ***that's at 1.5 gpm/ton***
  - **Lower flows through condenser (such as 15°F or 2 GPM/ton)**
    - ***that's something less than 3.0 gpm/ton***
  - **Resize the cooling tower accordingly**

Low Flow Chilled Water Plant Design …

What are other's saying???

- **Kelly and Chan (Vanderweil Engineering)**
  - HPAC January 1999: Optimizing Chilled Water Plants"
  - Chilled water ΔT: 18° & Condenser water ΔT: 14.2°F
  - *"With the same cost chillers, at worst, the annual operating cost with lower flows be about equal to "standard" flows but still at a lower first cost"*


CHILLED WATER PLANTS

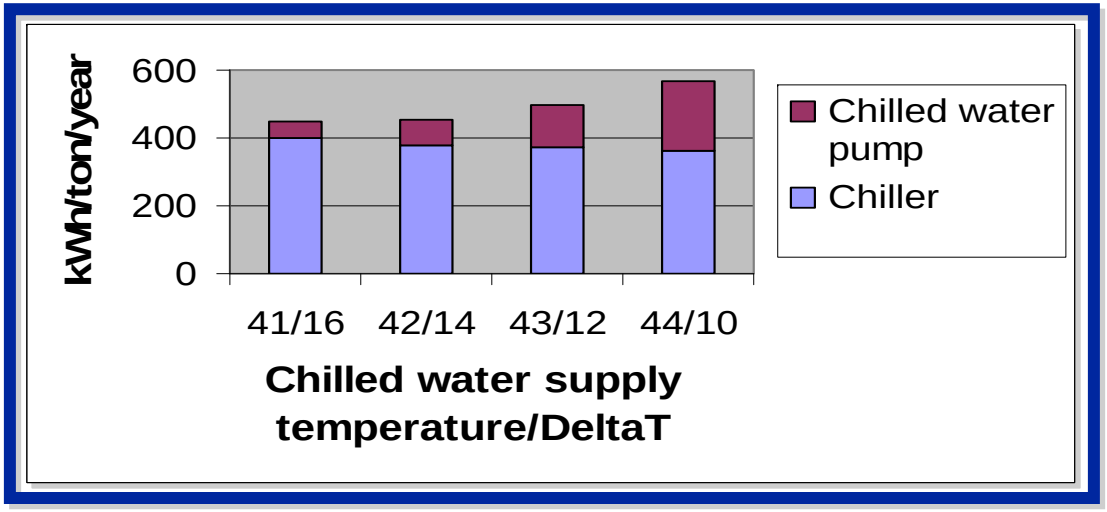
How the basic design parameters for chillers, pumps, and cooling towers can be optimized to accomplish both reduced energy usage and lowered first cost

Optimizing
Chilled Water Plants

By DAVID W. KELLY, Senior Corporate Engineer, and TUMIN CHAN, Corporate Engineer, R.G. Vanderweil Engineers, Inc., Boston, Mass.

Historical perspective

- **PG&E: CoolTools™**
  - Chilled water ΔT: 12°F to 20 °F
  - Condenser water ΔT: 12°F to 18 °F (multi-stage)



Non-Standard Part Load Value (NPLV)

- **The NPLV Averages the kW/ton at different loads**

$$NPLV = \frac{1}{\frac{.01}{A} + \frac{.42}{B} + \frac{.45}{C} + \frac{.12}{D}}$$

	A	B	C	D
Entering Tower Water -Expected →	85°	75°	65°	65°

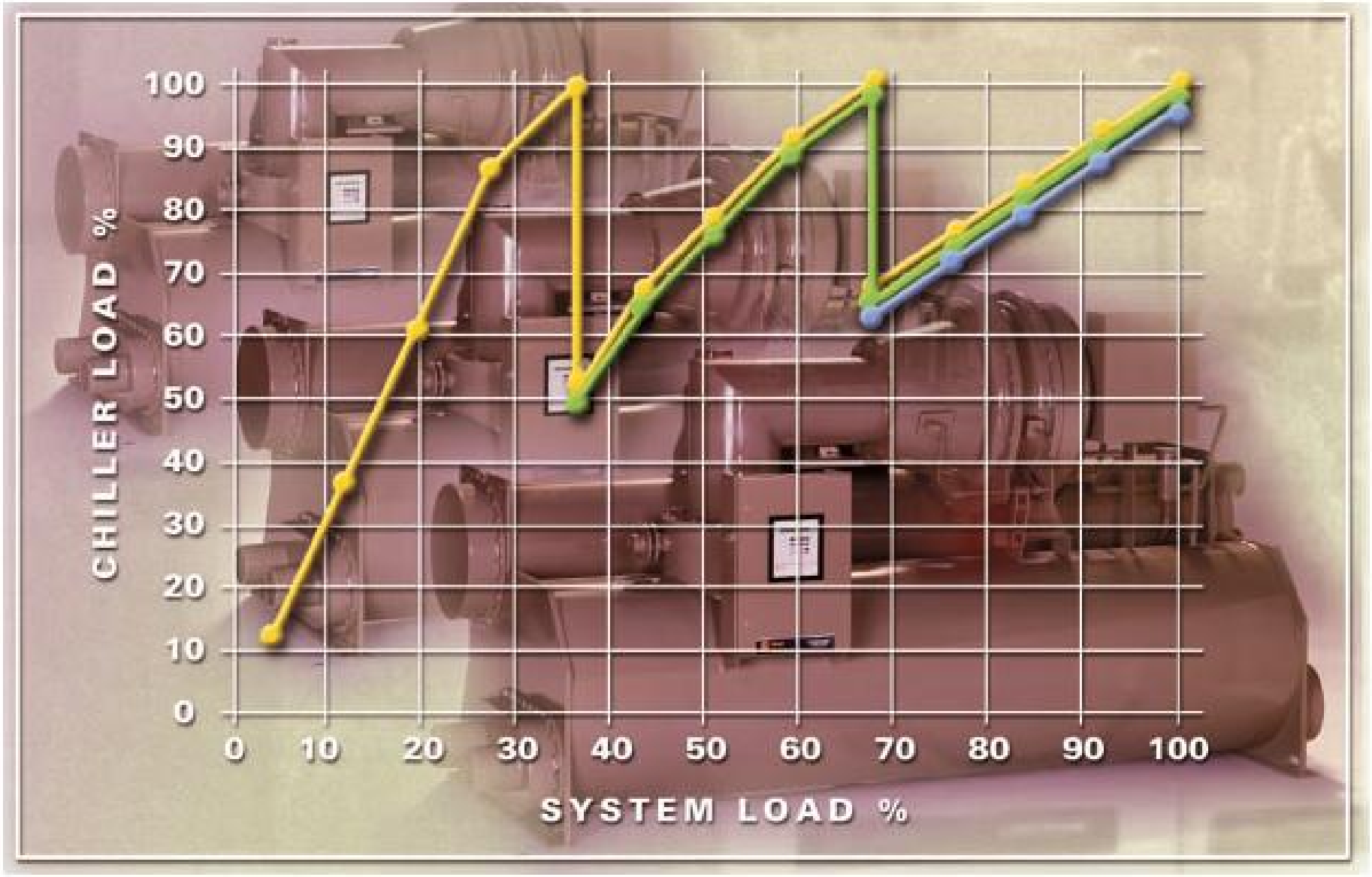
A= kW/Ton @ 100% Load
B= kW/Ton @ 75% Load
C= kW/Ton @ 50% Load
D= kW/Ton @ 25% Load

Weighting based on a Single Chiller Plant ! !

Appendix D - Derivation of IPLV
ARI STD 550/590-1998

D2.1 Scope. This appendix is for equipment covered by this standard. The IPLV equations and procedure are intended to provide a consistent method for calculating a single number part load performance number for water chilling products. The equation was derived to provide a representation of the average part load efficiency for a single chiller only. However, it is best to use a comprehensive analysis that reflects the actual weather data, building load characteristics, operational hours, economizer capabilities and energy drawn by auxiliaries such as pumps and cooling towers, when calculating the chiller and system efficiency. This becomes increasingly important with multiple chiller systems because individual chillers operating within multiple chiller systems are more heavily loaded than single chillers within a single chiller systems.

Multiple Chiller Plants



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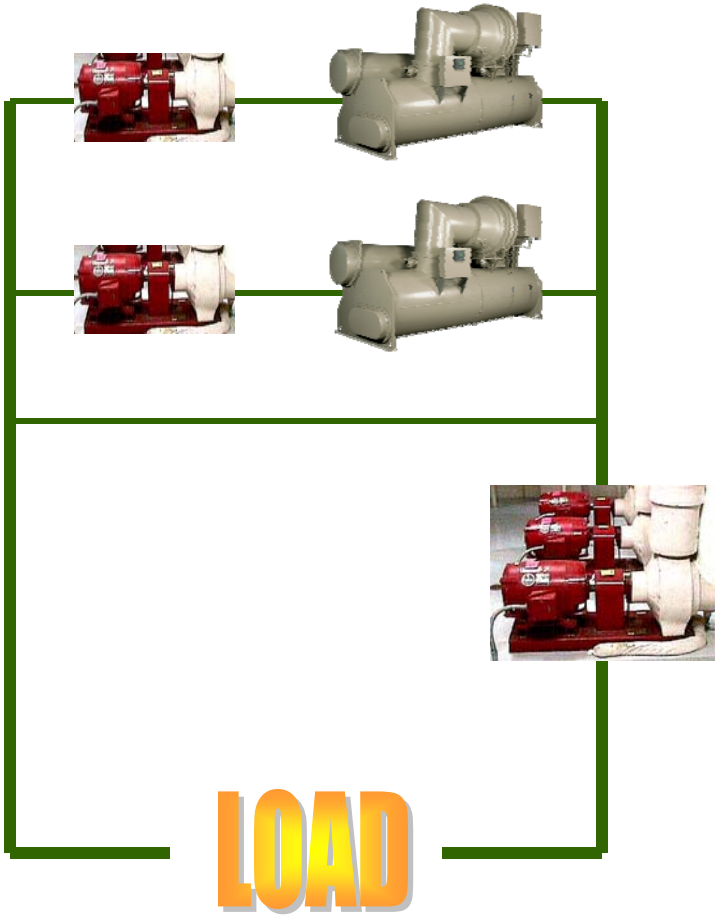
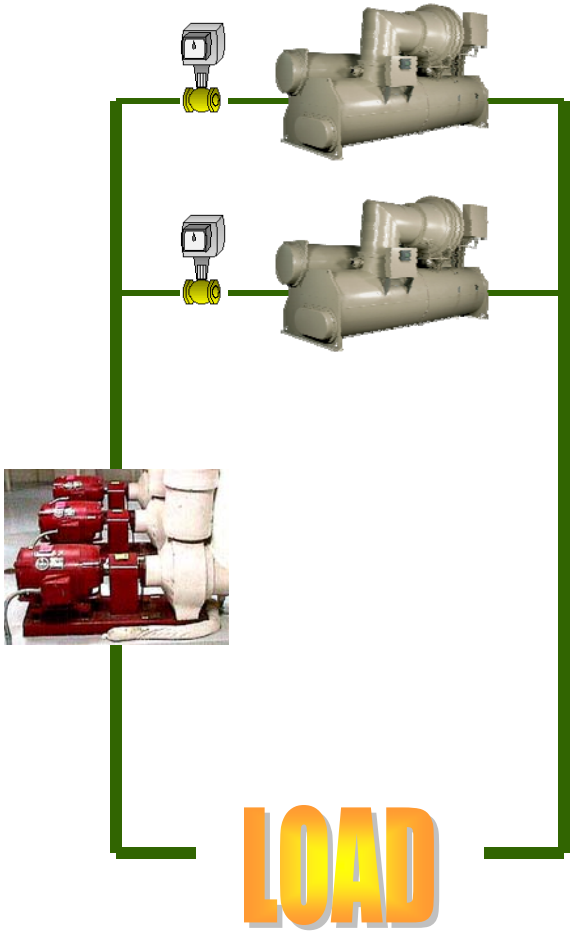
Factory Engineered and Commissioned unit level controllers

- **Incredibly accurate control**
- **Highly reliable control**
- **Adaptive control**
- **Multiple diagnostics**
- **Data rich user interface**
- **Variable primary flow optimizing options**

The Next Step...

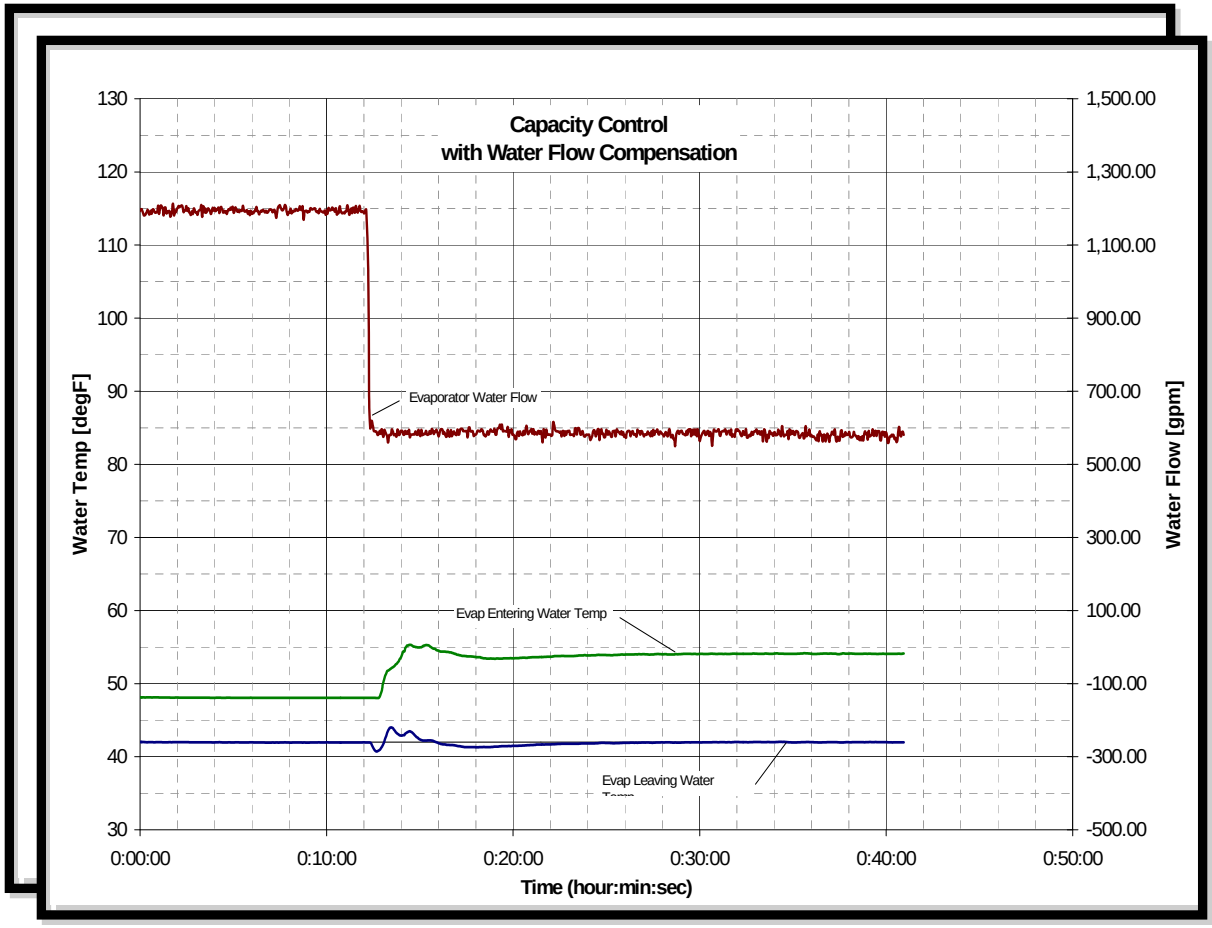
Decoupled System → VPF





Enabled Chillers Respond...

- **"Feed Forward" Controllers**
  - Most Reliable
  - Most Versatile



Tracer AdaptiView Control System

Process Control Enhancing Features

- **Adaptive control**
  - Reliable operation at maximum safe capacity through difficult operation conditions
- **Standard Motor Winding Temperatures Sensors**
  - Allow for multiple rapid restarts – eliminates “guessing” at restart delay requirements
- **Optional - Separate 460/480 Control Power X-former** (CPTR)
  - **For connection to uninterruptible power**
  - **Allows faster recovery after power loss**

Tracer AdaptiView Control System

Restart Inhibit

- **Free Starts**
  - Allows multiple restarts without fixed time delay
  - 1-5 (default 3)
- **Post Free Start - Restart Inhibit Start to Start Time Delay**
  - Prevents unintended harmful cycling
  - 10-30 min (default 20 min)
- **Stop to Start Time**
  - Allows for motor demagnetization
  - 5-30 seconds (default 30 sec)

AdaptiView™

Virtual Graphics on the Equipment

Data Points from Chiller Hardware

- **2 Chilled and 2 Condenser Water temps**
- **Refrigerant temps in evaporator & condenser**
- **Field provided flow meter**
- **Start and Run time counters**
- **kW power meter (not current amps)**

→ **Capacity, delta T's, %Loaded, HX approach**

Data Points from the System

- Ambient - db and wb
- kW Power from pumps, towers, chiller
- System Supply and Condenser Wtr Temps
- Total Capacity, kw/Ton

→ Capacity, delta T's, %Loaded, HX approach

Validating for Sustainability

- **System kW /Ton Vs…..**
  - **Key ambient temp (wb-wc / db-ac)**
  - **Total capacity**
  - **Unit aver run time and hours per start.**
  - **Sample of 1 per hour**
  - **Compare to the typical value range at various amb. conditions**
  - Note: System = compressor + transport + heat-of-rejection power

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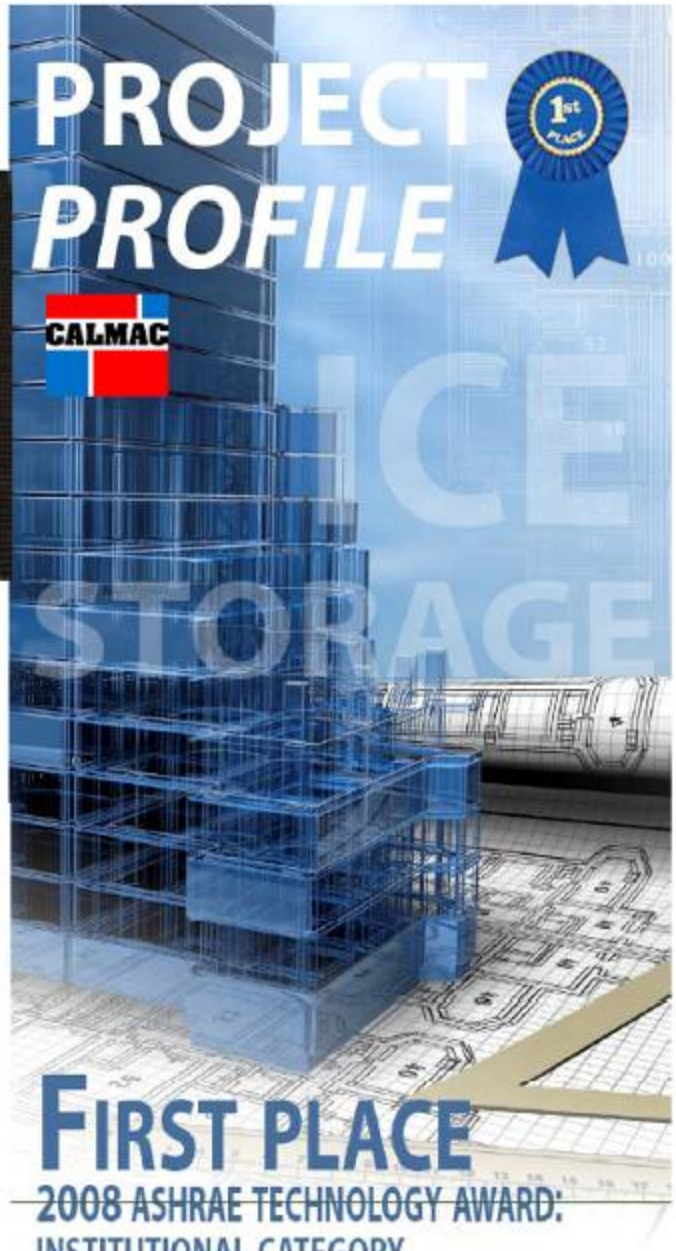
PROJECT PROFILE

CALMAC



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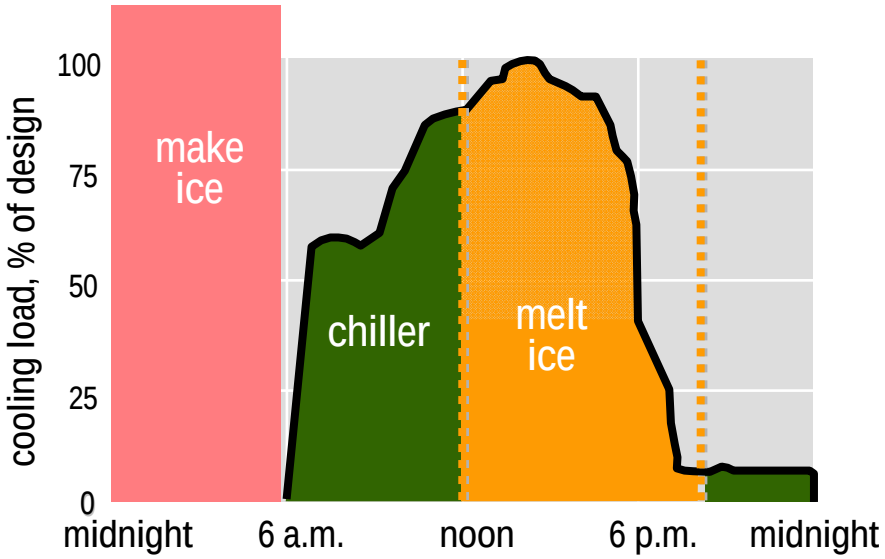
  - Leverage real-time pricing
- **Uses your “HEAD”**

ice storage

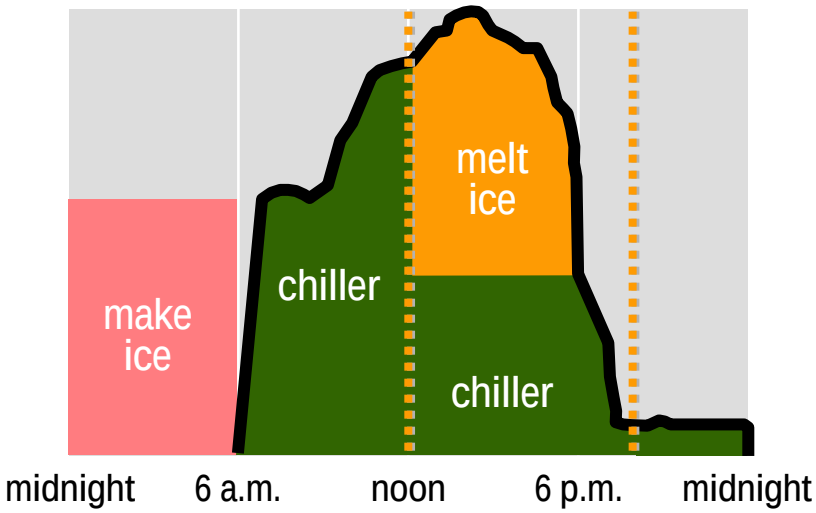
Full vs Partial Storage

full storage



large chiller & lots of ice

partial storage



downsized chiller & a little ice

Opportunities Summary

- Optimize on the “selection parameters”
- New Performance Rating method suited for multiple chiller plants to replace NPLV
- Document the system performance
- Consider a more rigorous analysis of the benefits of TES with assets.
- Ask for chiller options with adaptive controls