EPRI 2008

Closed-Loop, Evaporative Cooling Systems

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Agenda

- Closed-loop, evaporative cooling systems
  Wet Surface Air Coolers (WSAC)
- Technology comparison
- Applications
- Water and energy savings
- Summary/questions

What is a Wet Surface Air Cooler?

- Heat removal device
  - Cooling liquids
  - Condensing vapors

Wet Surface Air Cooler

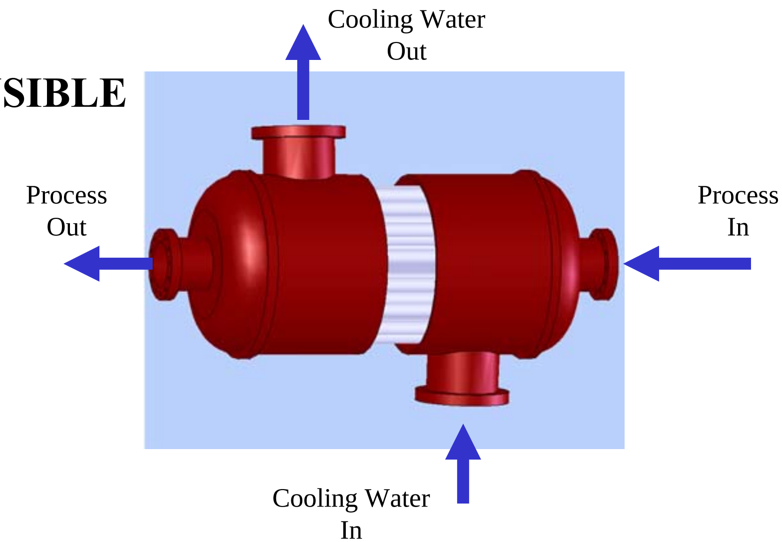
- Where is it applicable?
  - Aux loop cooling
  - Direct vacuum steam condensing
  - Refrigerant condensing
  - Lowering discharge water temperature

- Where is it being used?
  - Numerous simple and combined cycle power plants worldwide

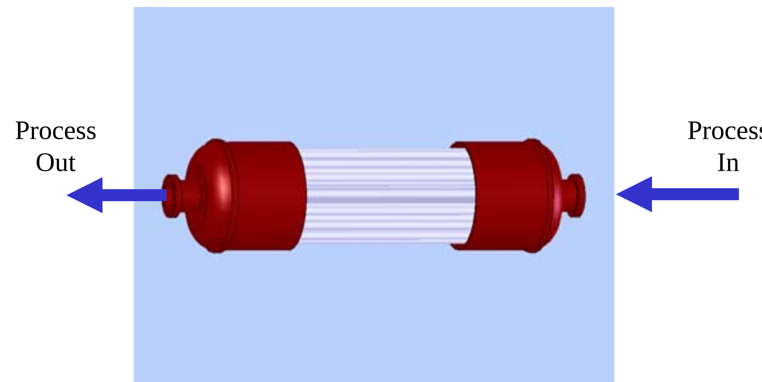
How Does the WSAC Work?

1.) Typical Shell & Tube Heat Exchanger

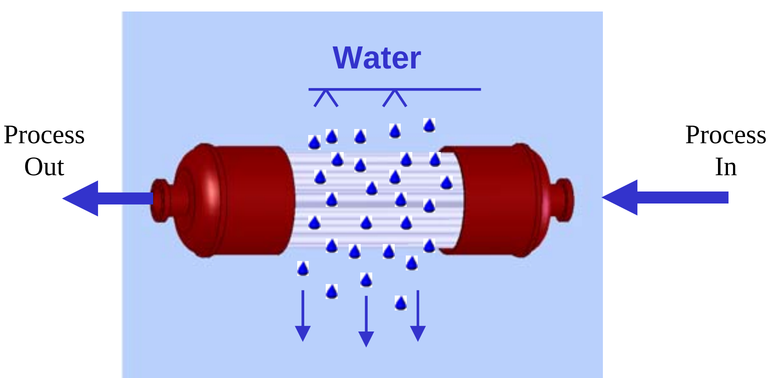
SENSIBLE



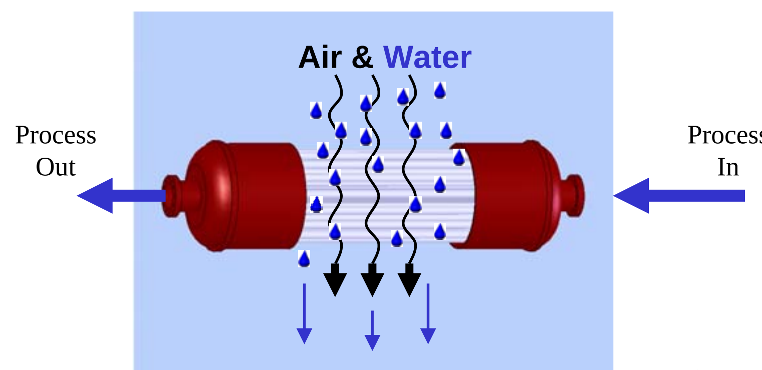
2.) Remove "Shell" Exposing Tubes



3.) Spray Water Directly Over the Exposed Tubes



4.) Air is Induced Over Tubes in the Same Direction as the Water



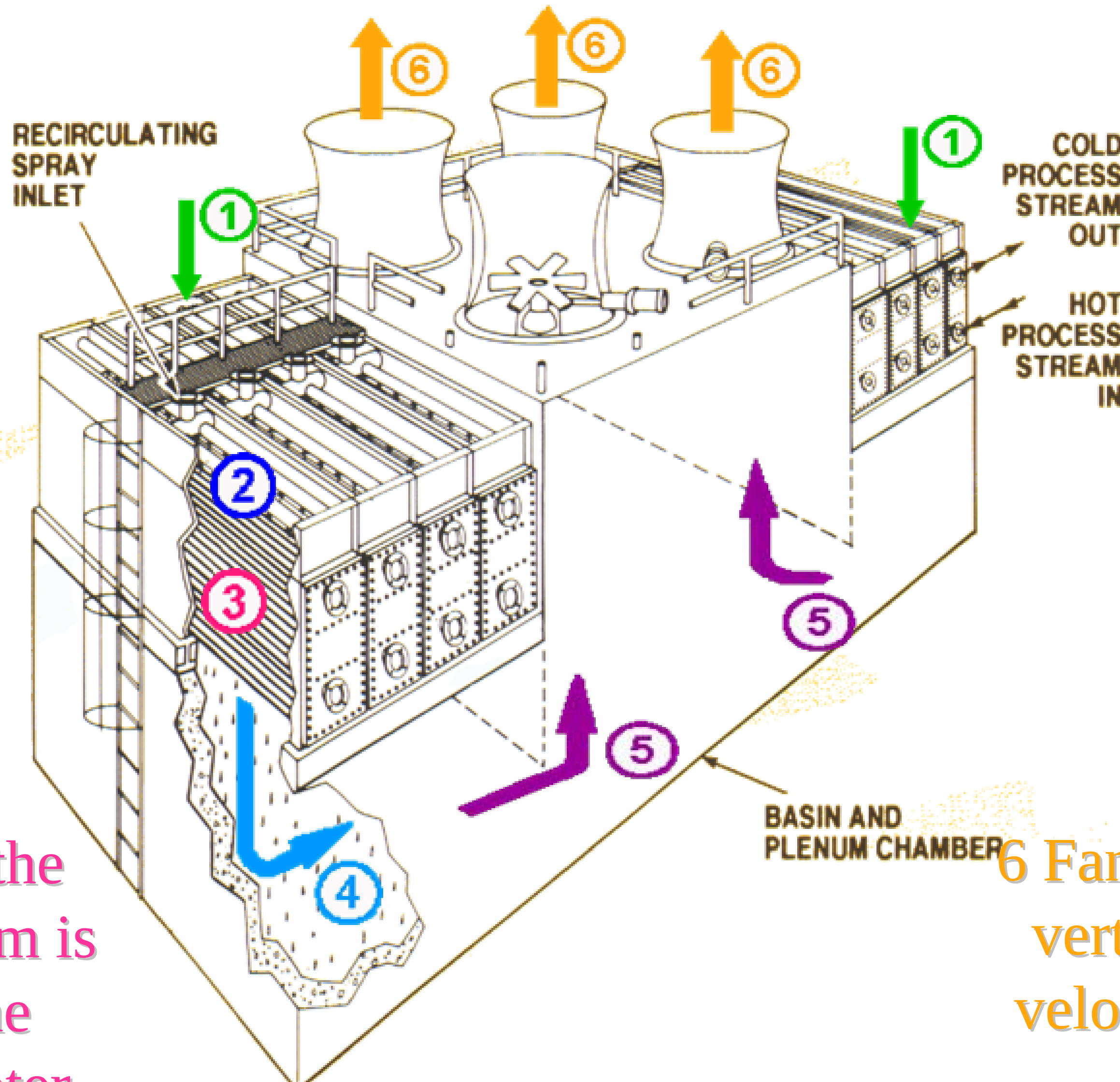
LATENT

How Does the WSAC Work?

1 Air is induced downward over tube bundles

2 Water flows downward along with the air

3 Heat from the process stream is released to the cascading water



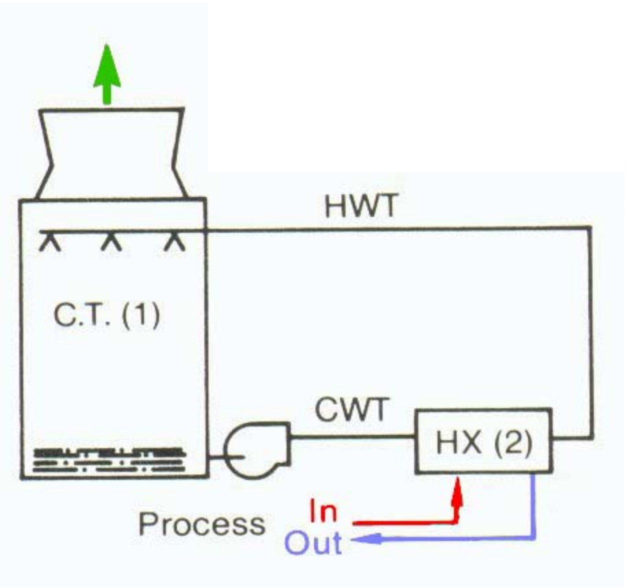
4 Heat is transferred from the cascading water to the air stream via vaporization

5 Air stream forced to turn 180º providing maximum free water removal

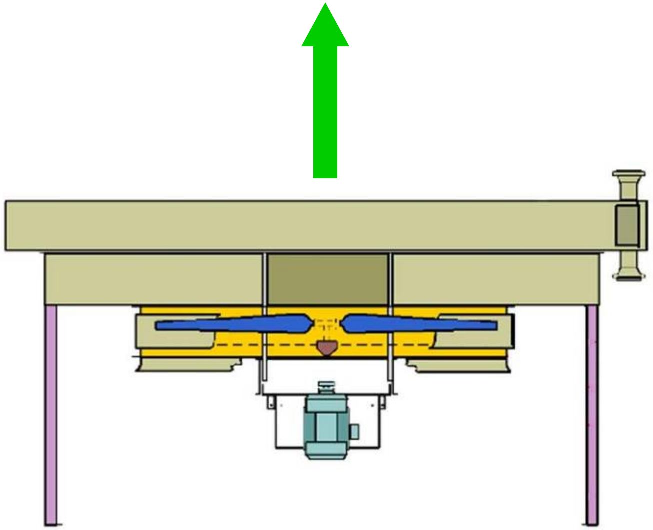
6 Fans discharge air vertically at a high velocity preventing recirculation

Cooling Technology Options

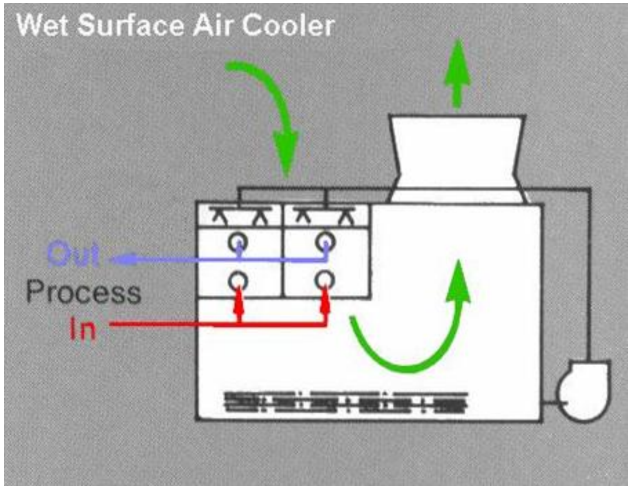
Cooling Tower / Heat Exchanger



Dry / Air Cooled



Wet Surface Air Cooler (WSAC)



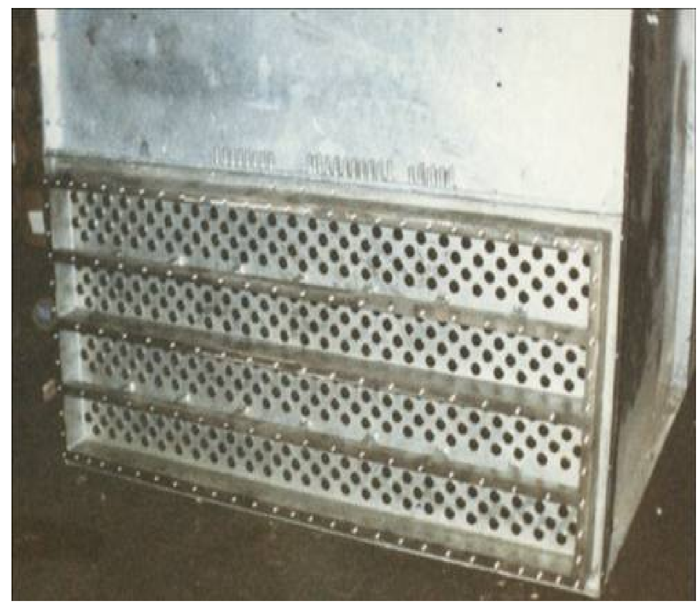
Equipment Configuration

Factory Assembled

Field Erected

General Specifications

Serpentine Coils *or* *Bolted Straight Through Bundles*

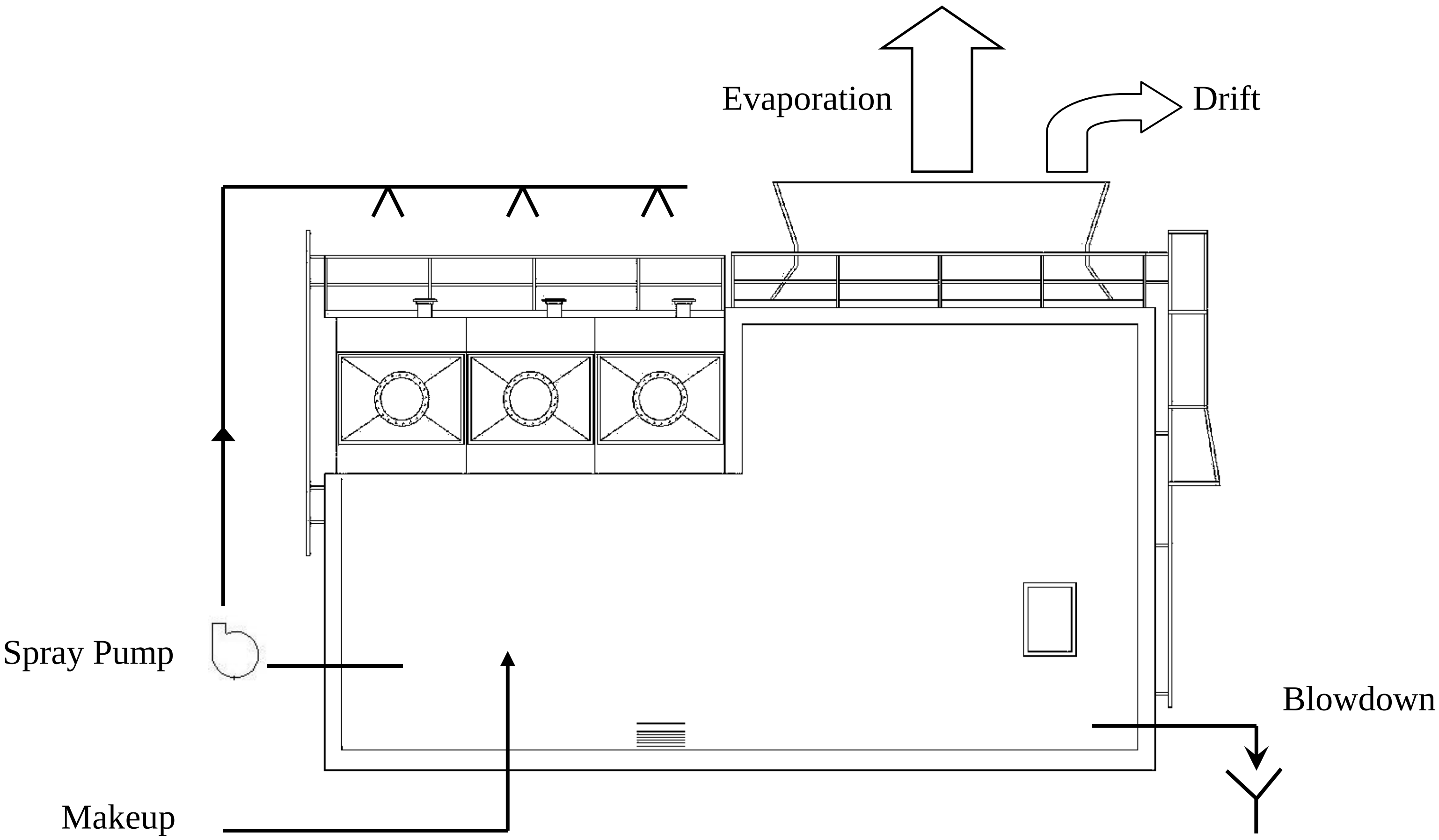


General Specifications for WSAC

- Spray Water Distribution System

  - Low-pressure / High-flow design
  - Full flooded spray pattern
  - No fill

Water Issues

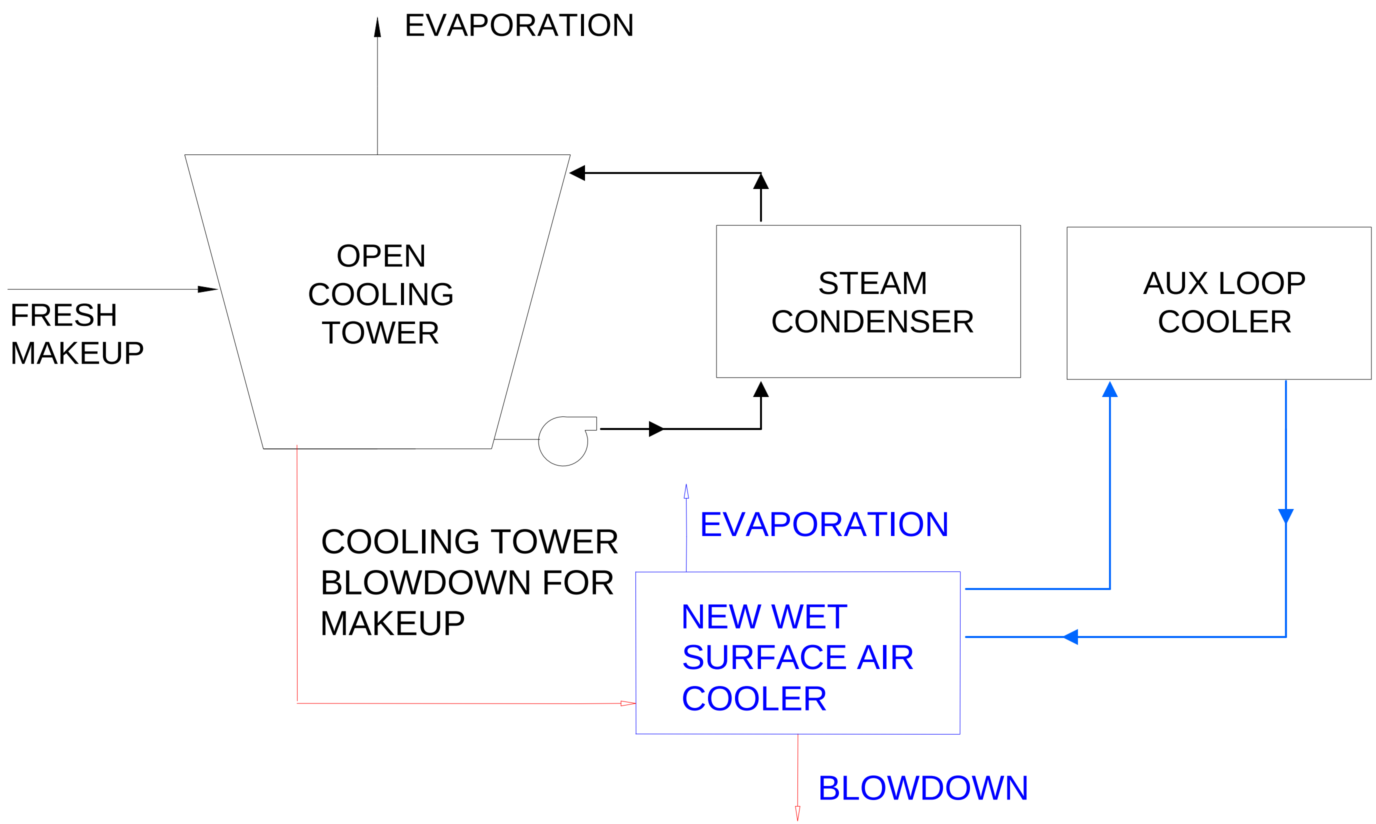


EVAPORATION(GPM) = HEAT LOAD (Btu/hr)/570,000

MAKEUP = EVAPORATION + BLOWDOWN + DRIFT

CYCLES OF CONCENTRATION = (EVAPORATION / BLOWDOWN) +1

Reducing Water Makeup in Existing Open-Loop Systems

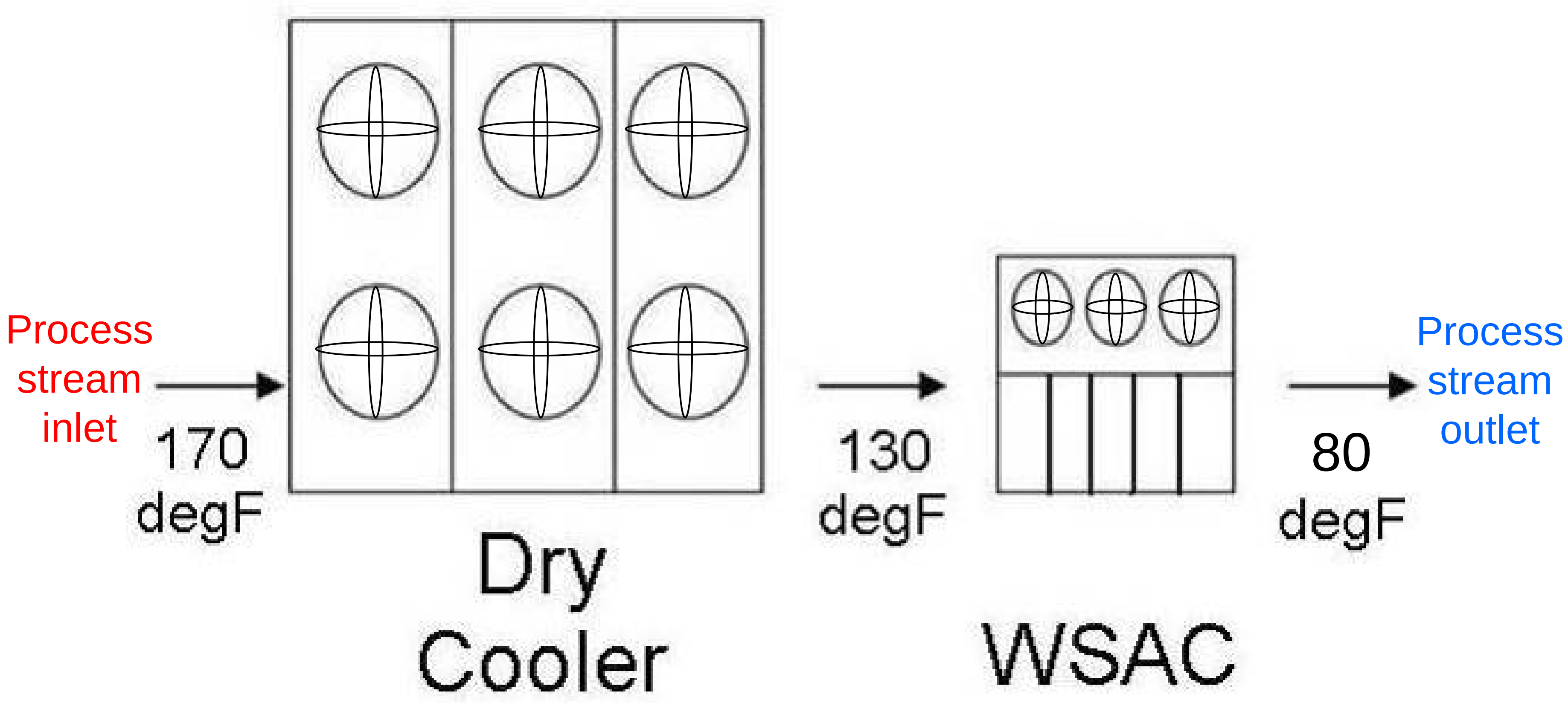


SAVINGS: 525 MW plant →60 million gal/yr

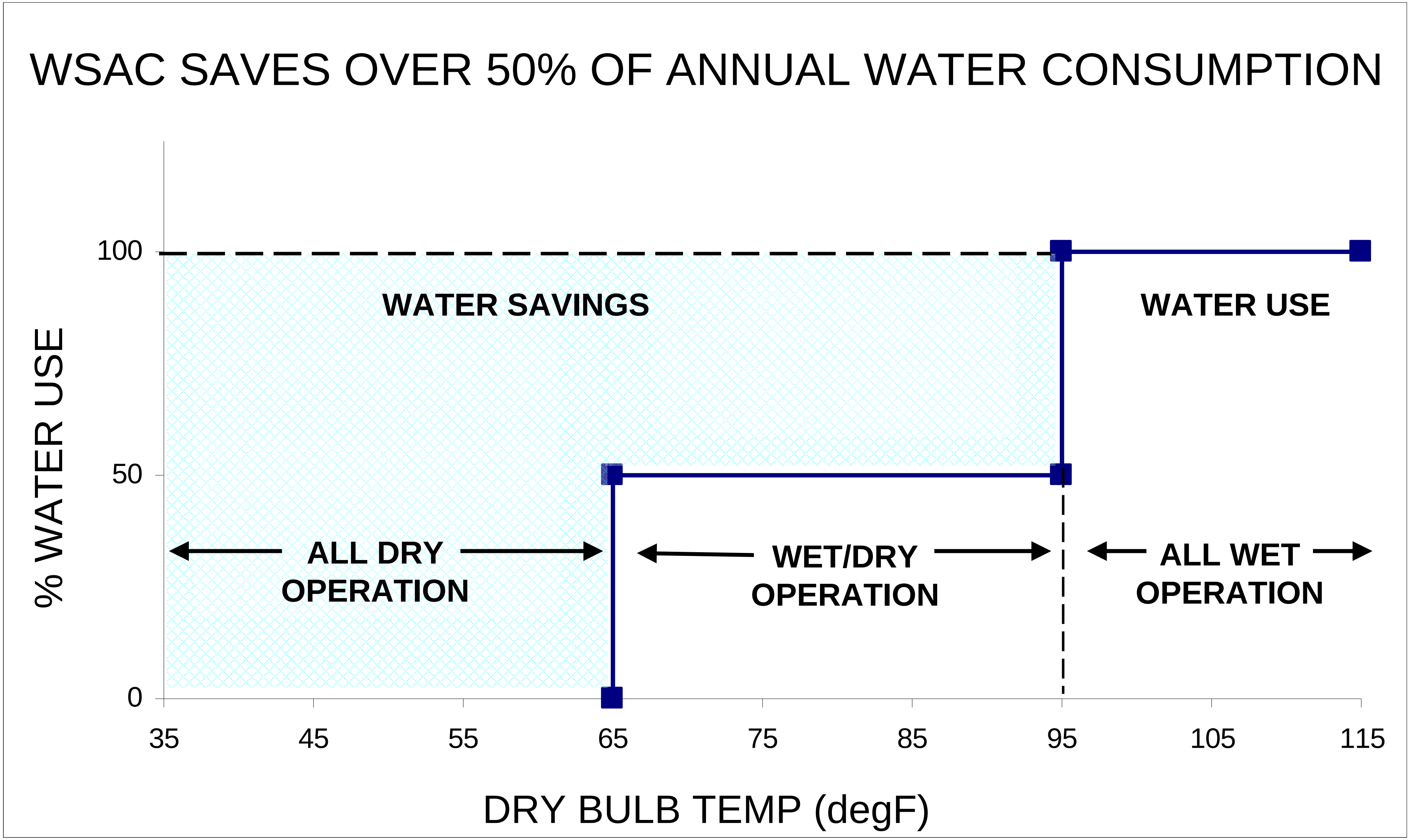
Aux Loop Cooler

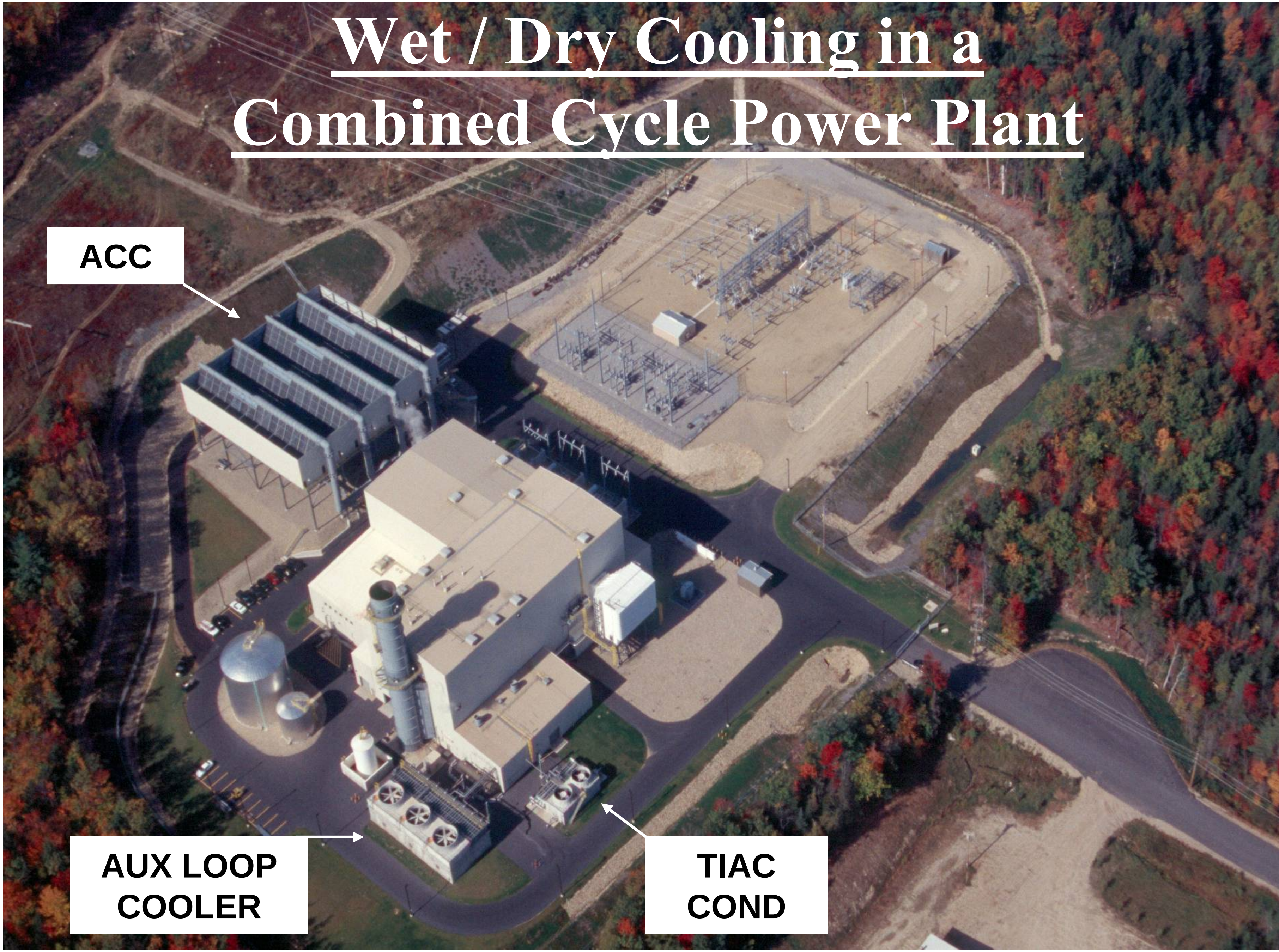
Schematic of Dry/Wet Cooler

Cooling to 80°F at 95°F DB / 70°F WB

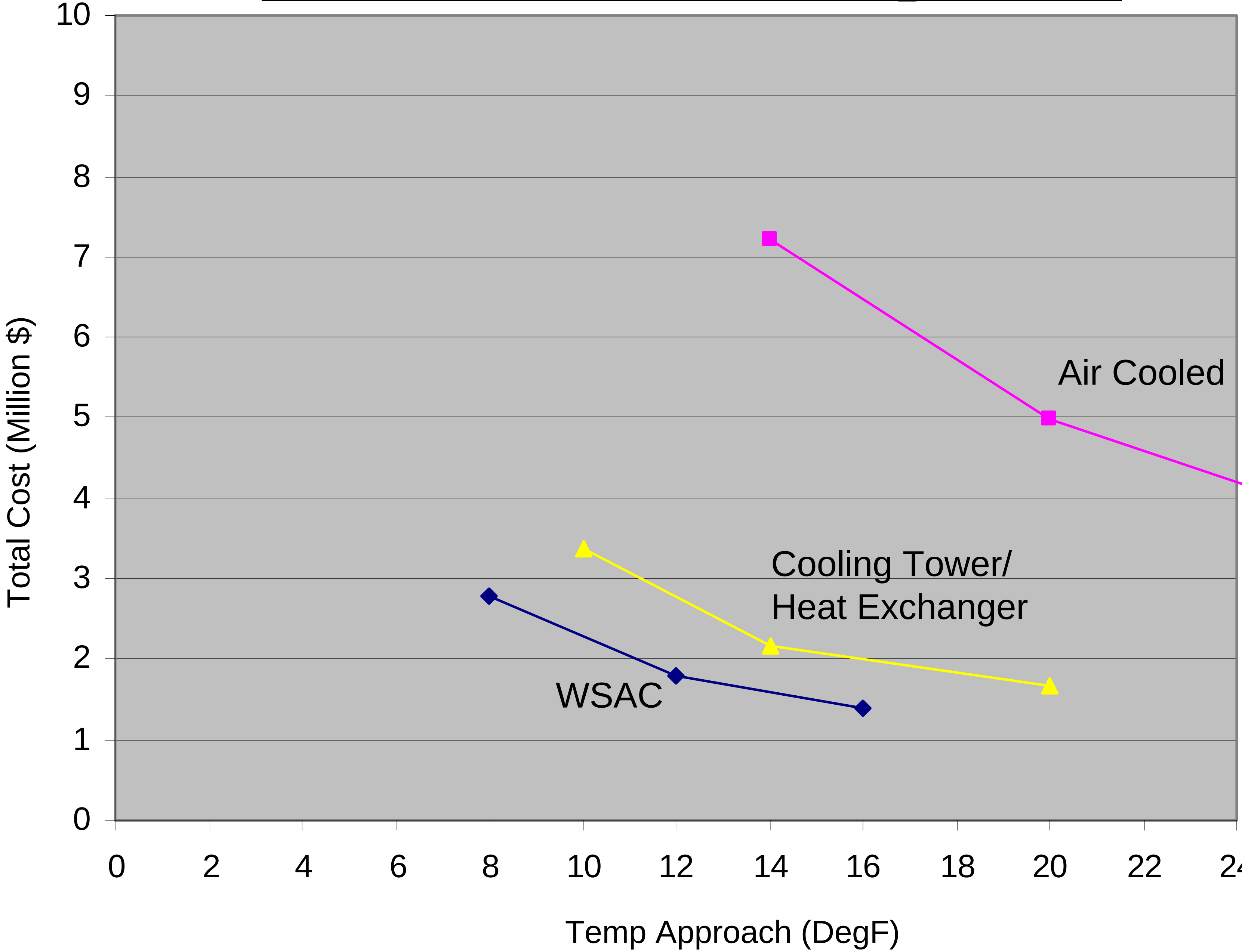


Water Savings Using Niagara Dry/WSAC



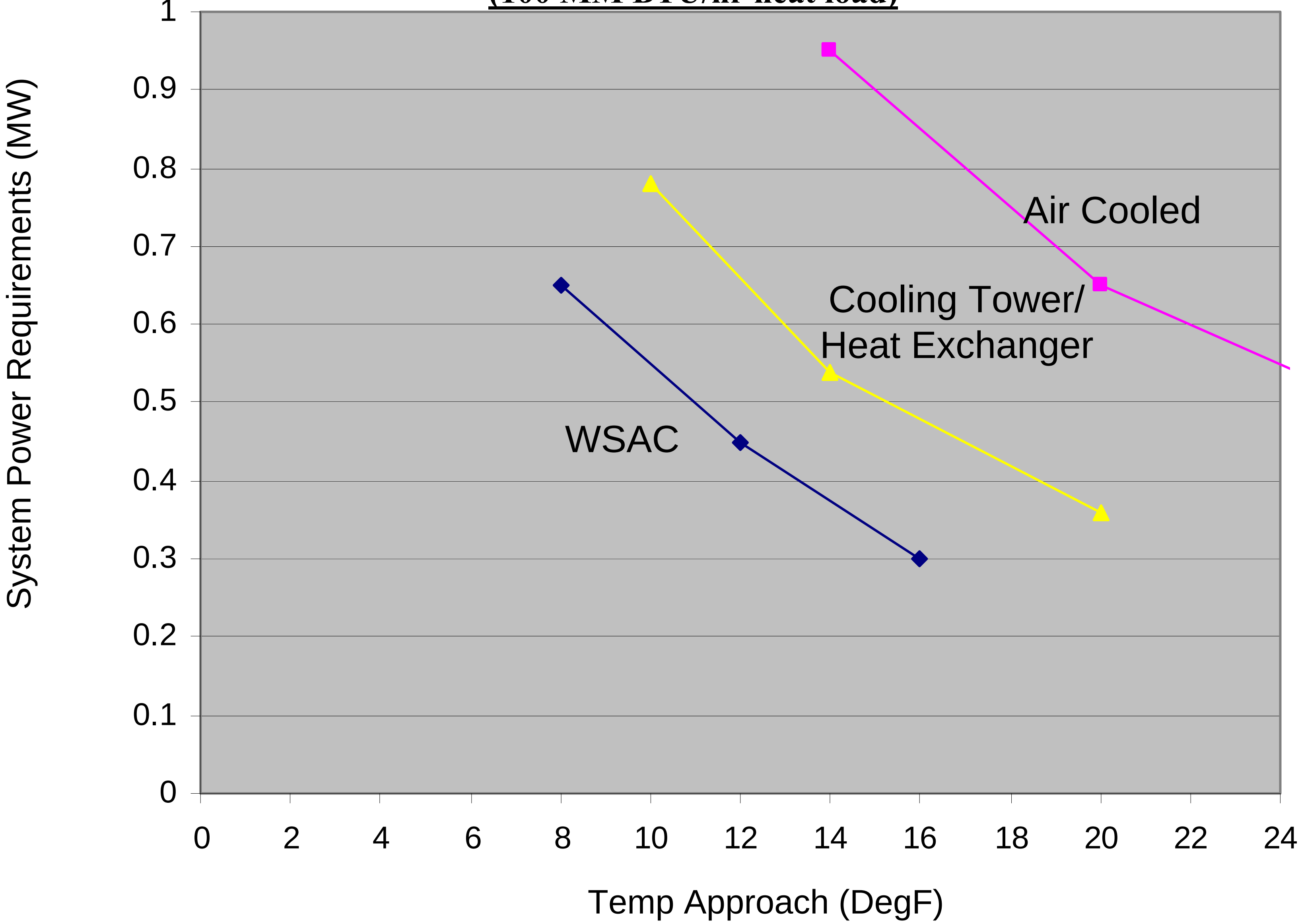

Wet / Dry Cooling in a
Combined Cycle Power Plant
ACC
AUX LOOP
COOLER
TIAC
COND

Condenser Cost Comparison



Comparison of Total Power Required vs. Approach Temp

(100 MM BTU/hr heat load)



WSAC Benefits

- Pump less water
  - Lower horsepower
    - Reduced installation costs
    - More available power for sale
    - Lower carbon footprint

WSAC Benefits

Can use poor quality water

-Reuse plant water

-Brackish water, seawater

-Agricultural runoff

-FGD water

Can run higher cycles of concentration

- Less water to purchase
- Less water to dispose of

WSAC Benefits

Cocurrent spray system design

- Lower discharge height
- Lower PM10

WSAC Benefits

Can cool plant discharge water

- Reduced thermal effect

WSAC Benefits

Can evaporate blowdown

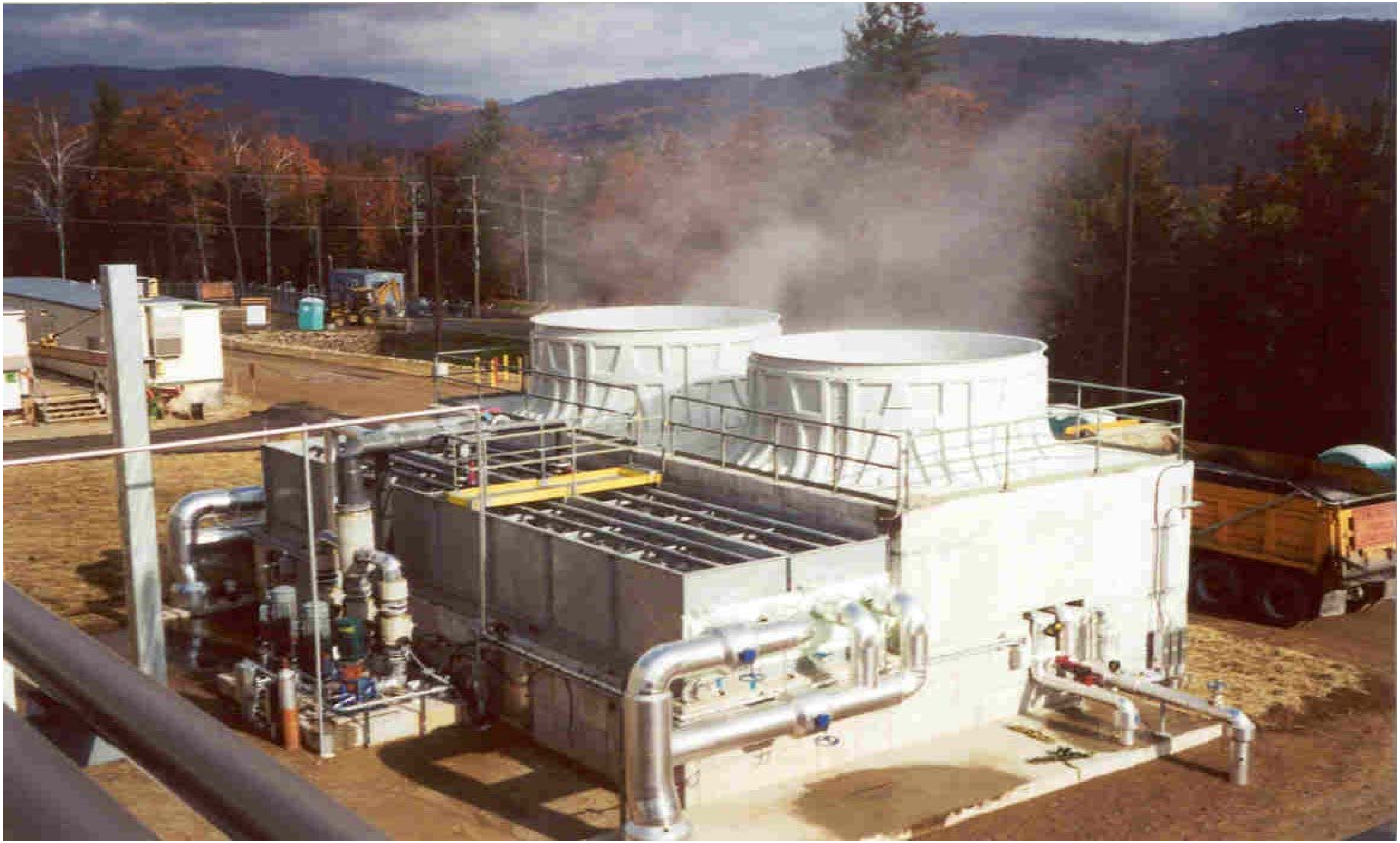
- Smaller evaporation ponds
- Less ZLD system capacity
- Cost savings

  "Expensive to own and operate"

Small Packaged Fluid Cooler

Large Gas Turbine Packaged Fluid Cooler

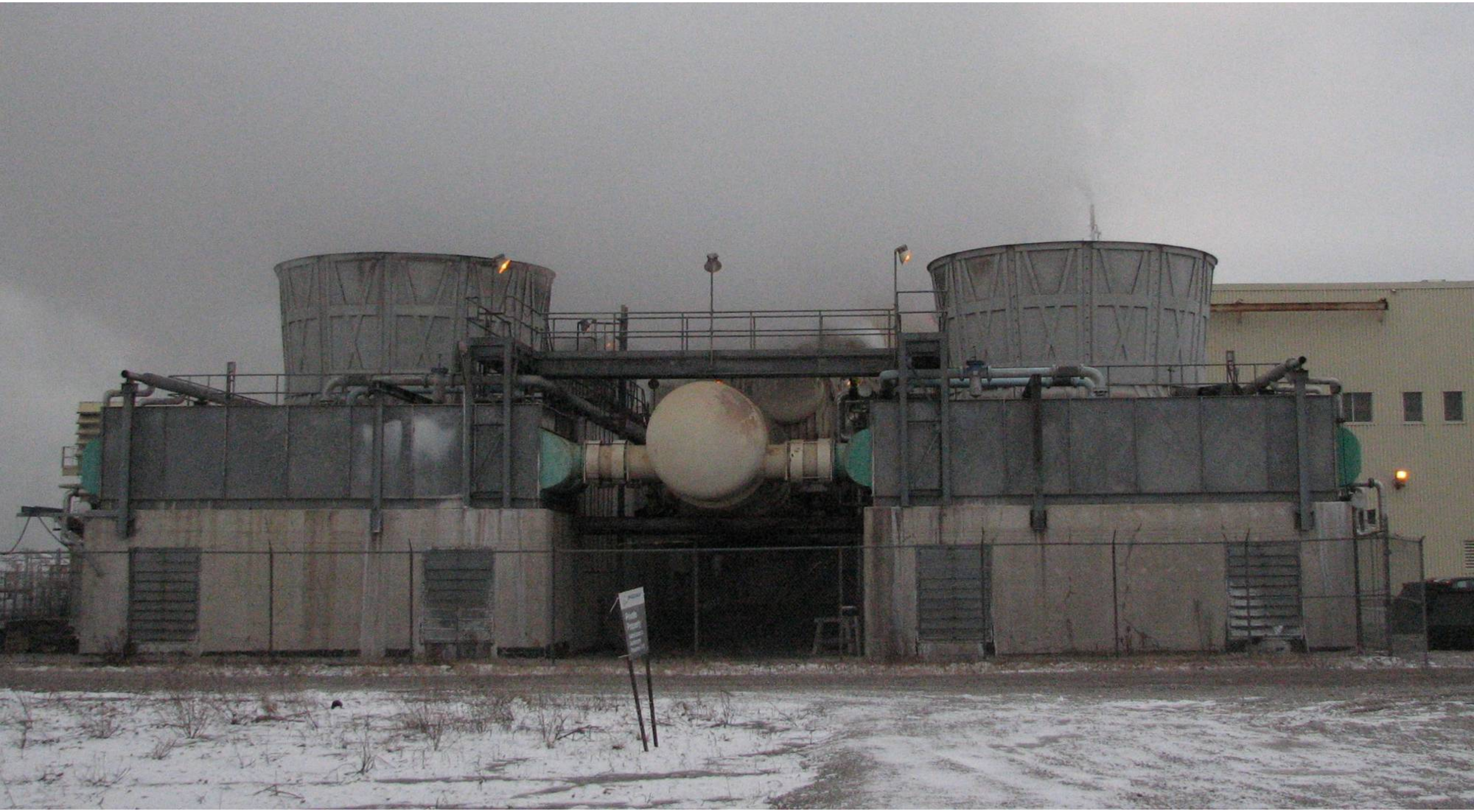
Combined Cycle Plant – Aux Loop Cooler



1100 GPM, 160°F Inlet Temp., 120°F Outlet Temp., 80°F Wet Bulb

Steam Condenser

Steam Condenser



670,000 lb/hr Steam Condensers and Auxiliary Fluid Cooler

12,000 Ton Ammonia Condenser

Griffith, AZ

Summary

- More efficient cooling/condensing
- Improved heat rate
- Less HP
- Lower carbon footprint
- Less maintenance
- Water savings

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