Closed-Cycle Wet Cooling

ASME-IMECE Congress NSF-EPRI Workshop 11/13/2012

By: Jean-Pierre Libert

Introduction

- Heat generated in power plants must be dissipated.
- Natural bodies of water cannot sustain unlimited amounts of heat.

Clean Water Act

- The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters

NPDES

- As authorized by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States

CWA Section 316(b)

- Section 316(b) of the CWA requires that NPDES permits for facilities with cooling water intake structures ensure that the location, design, construction and capacity of the structures reflect the best technology available to minimize harmful impacts on the environment.

Indirect Cooling

- Indirect Cooling: surface condenser + …
  - Once-through
  - Once-through with helper cooling tower
  - Wet or wet-dry cooling tower
  - Dry air cooler
  - Heller System (DC condenser)

Direct Condensing or PCS

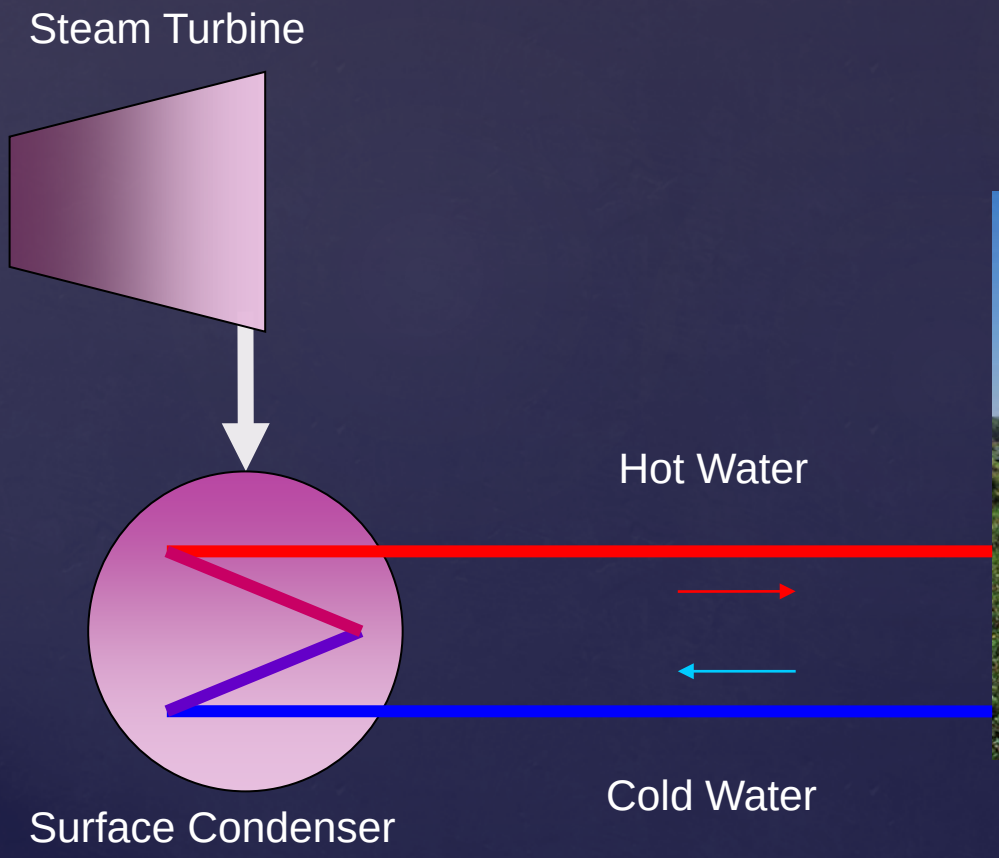
- Direct Condensing
  - Air Cooled Steam Condenser (ACC)
- Parallel Condensing (PCS)
  - ACC in parallel with Cooling Tower + Surface Condenser

The future?

- Indirect wet (or wet-dry) cooling or direct condensing will eventually replace once-through.
- Water availability in many regions is becoming more restricted.
- Water cost on the rise everywhere.
- Evaluate direct condensing vs. indirect wet or wet-dry cooling systems.

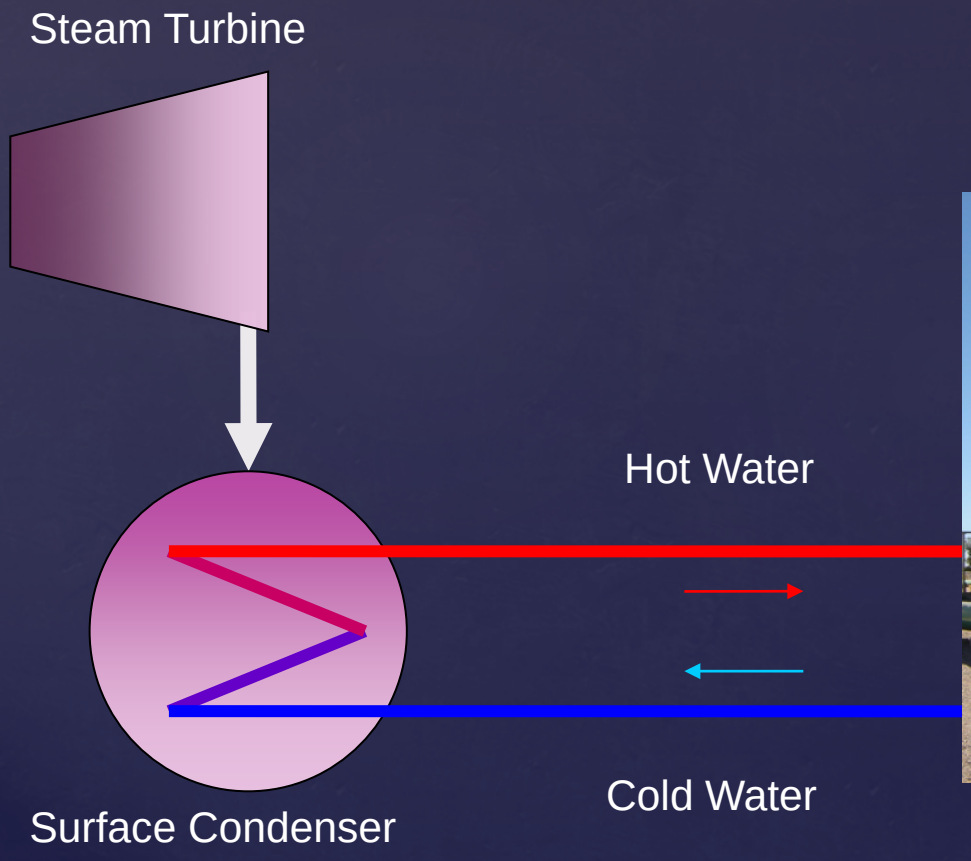
Indirect Wet or Wet-Dry Cooling

Once-Through

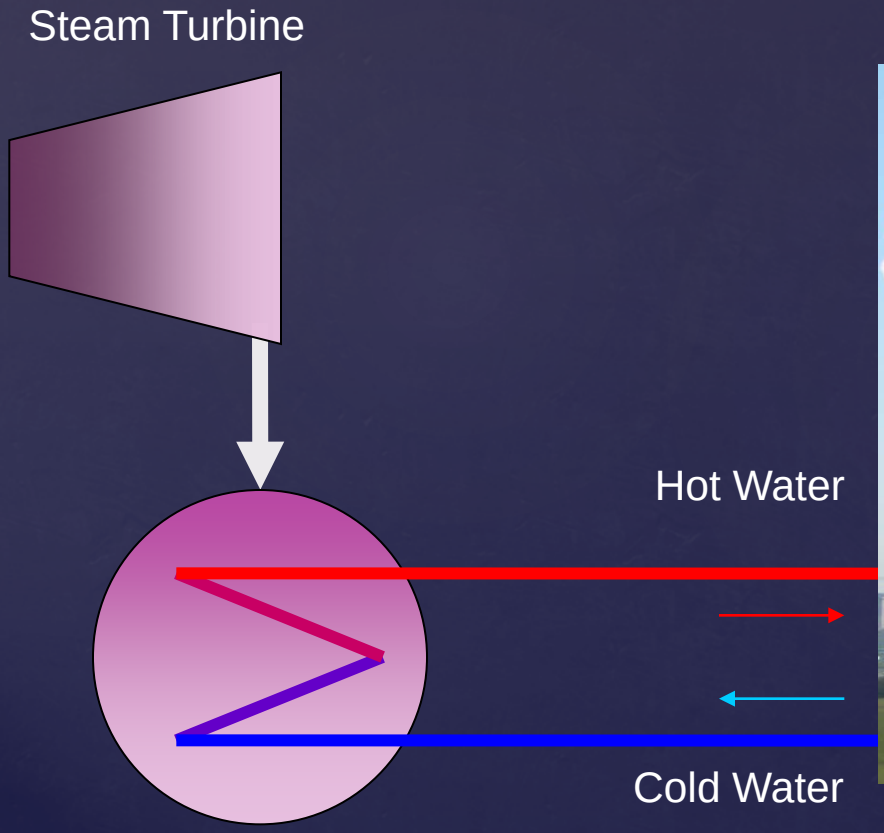


Once-Through with Helper

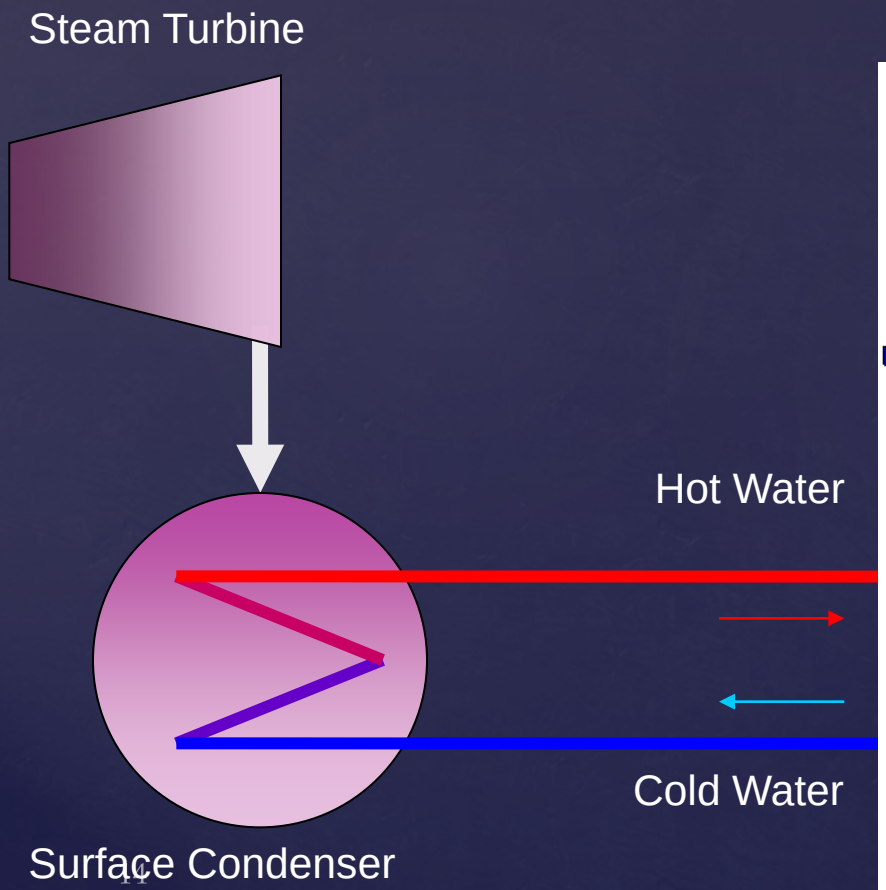
Closed Cycle Wet Cooling (MD)

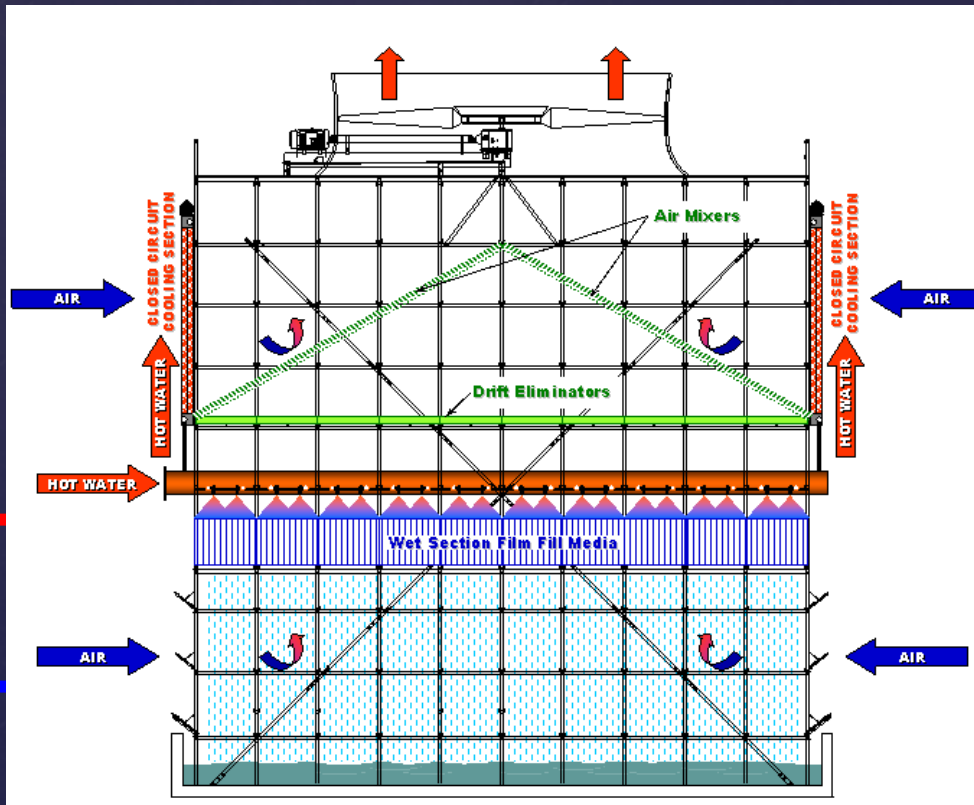


Closed Cycle Wet Cooling (ND)



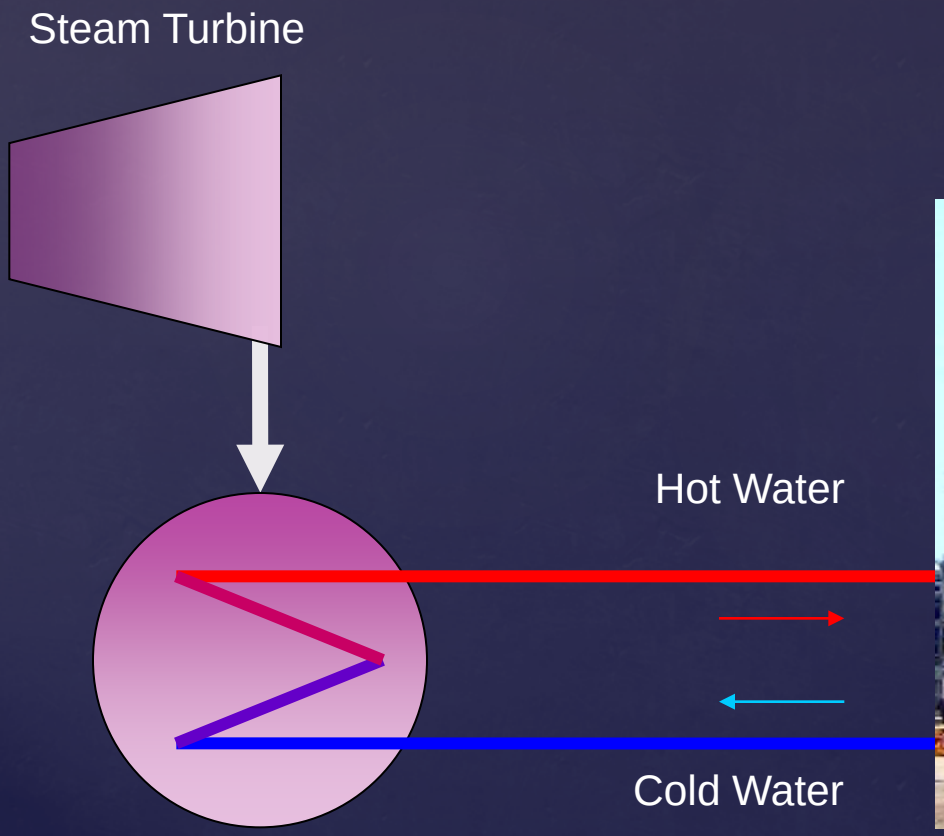
Closed Cycle Wet-Dry Cooling (example: PPWD)





Water Conservation / Plume Abatement

Closed Cycle Dry Cooling (MD)



Dry Cooling Heller System

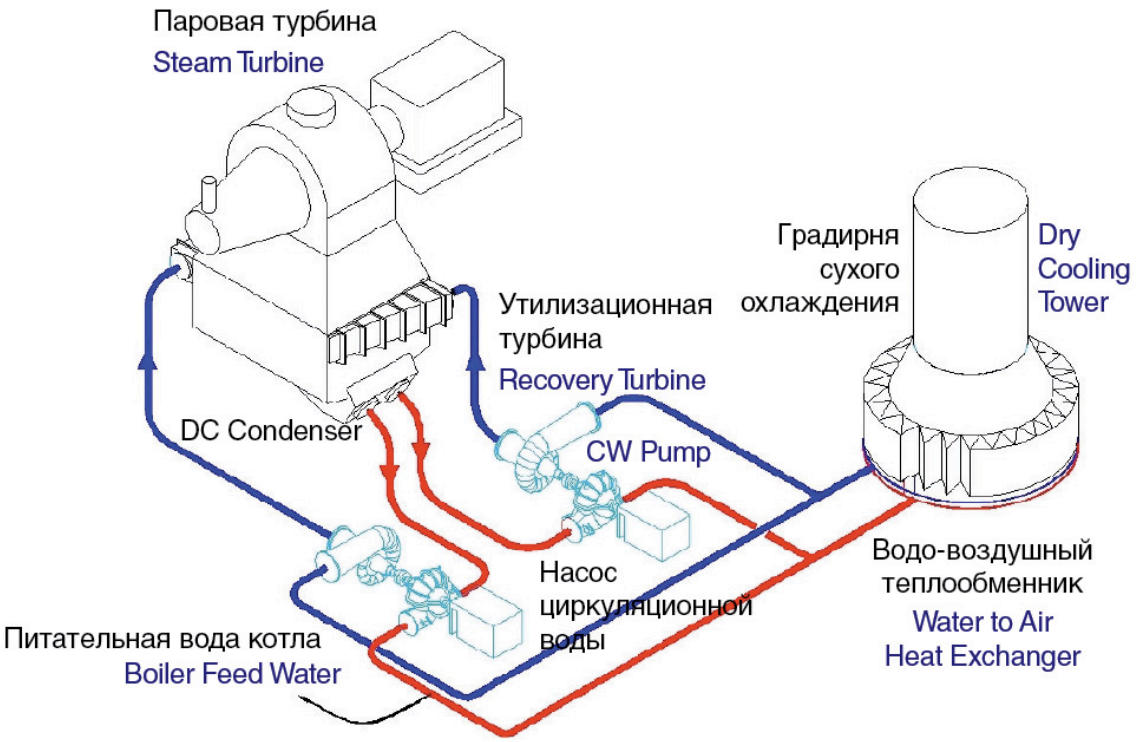


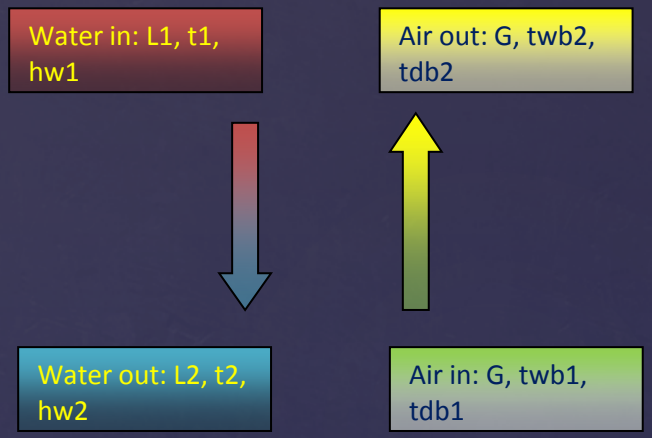
Рис. 2: Принципиальная схема системы Геллера со смешивающим конденсатором.

Fig. 2: Simplified flow diagram of HELLER System with DC Condenser

Courtesy GEA Energy Technology

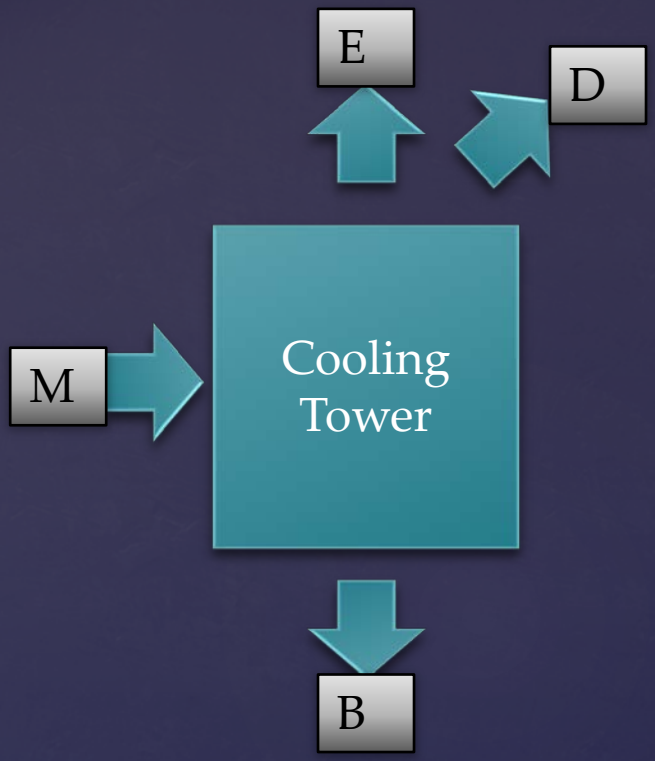
- Wet cooling systems produce a lower turbine backpressure than dry cooling systems so the turbine operates at higher efficiency, but…
- Wet cooling systems do consume water.

Energy-Water Nexus



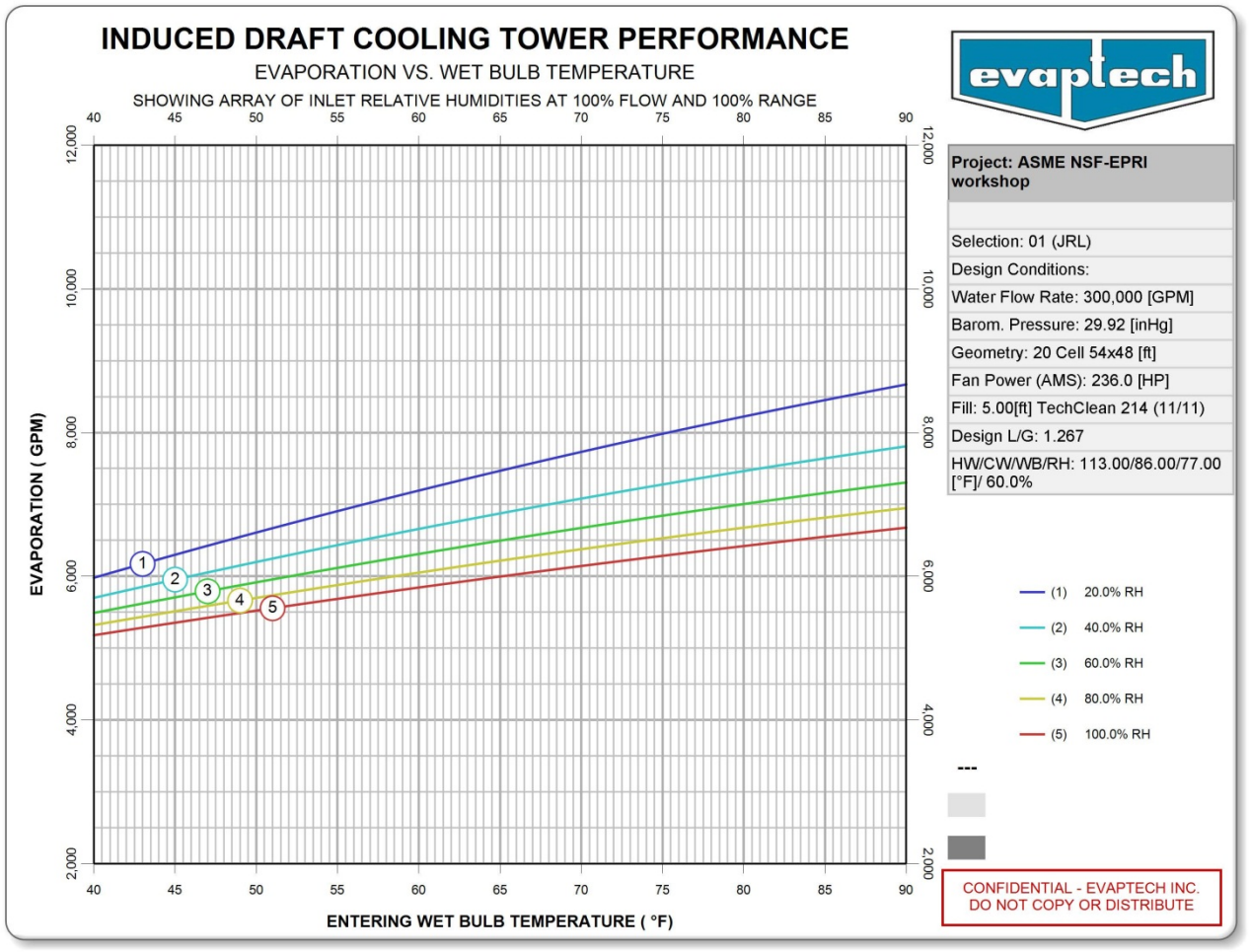
- Heat Balance:
- $cp\ L_1\ t_1 - cp\ L_2\ t_2 = G\ ha_2 - G\ ha_1$
- Mass Balance:
- $L_1 - L_2 = G\ (w_2 - w_1)$
- Evaporation = $G\ (w_2 - w_1)$
- Evaporation % = $G/L_1\ (w_2 - w_1)$

Thermodynamics of Wet Cooling

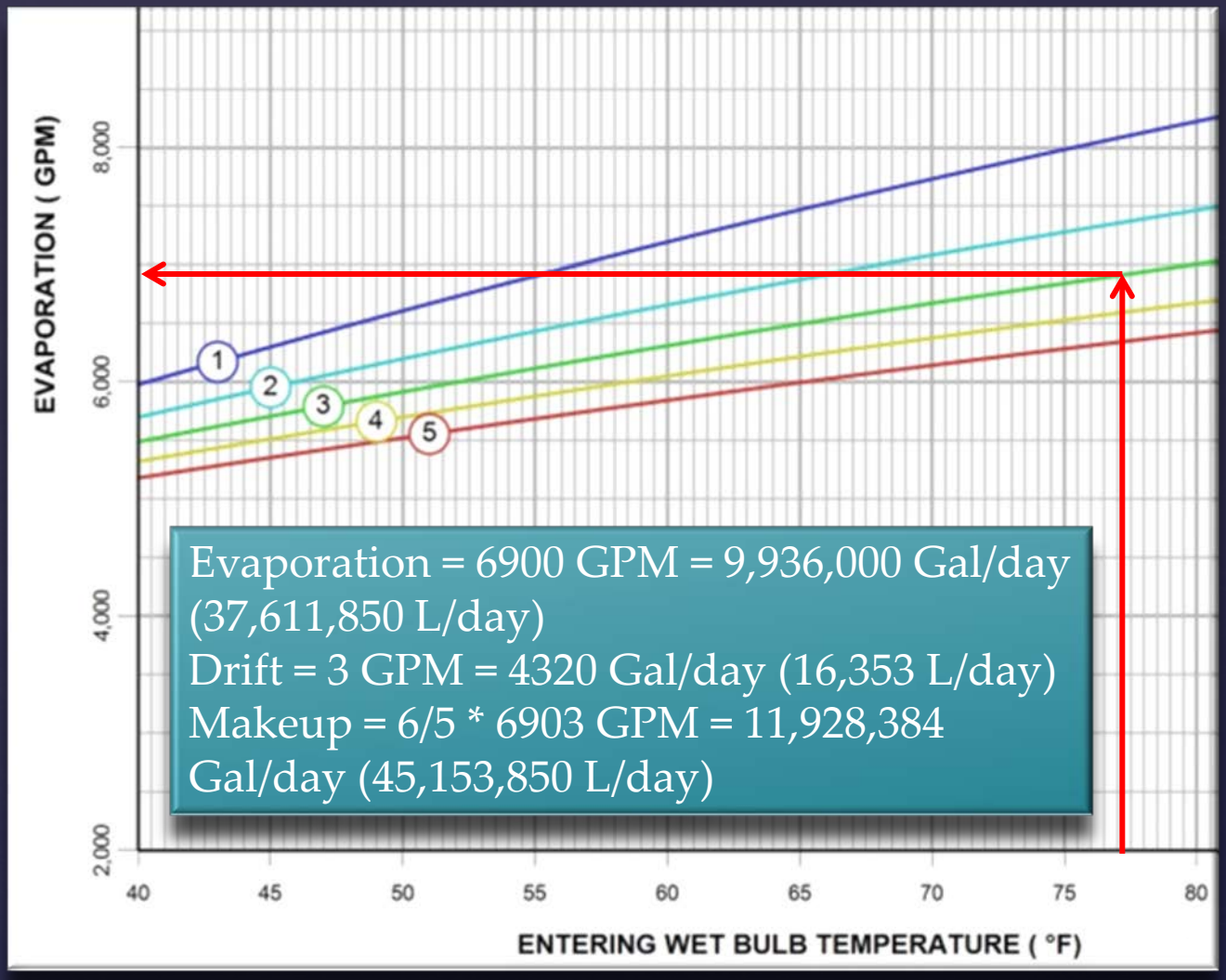


- Makeup = M
- Evaporation = E
- Bleed = B
- Drift = D
- M = E + B + D
- Cycles of Concentration = CC
- CC = M / B
- M = CC / (CC-1) x (E+D)

Water Consumption

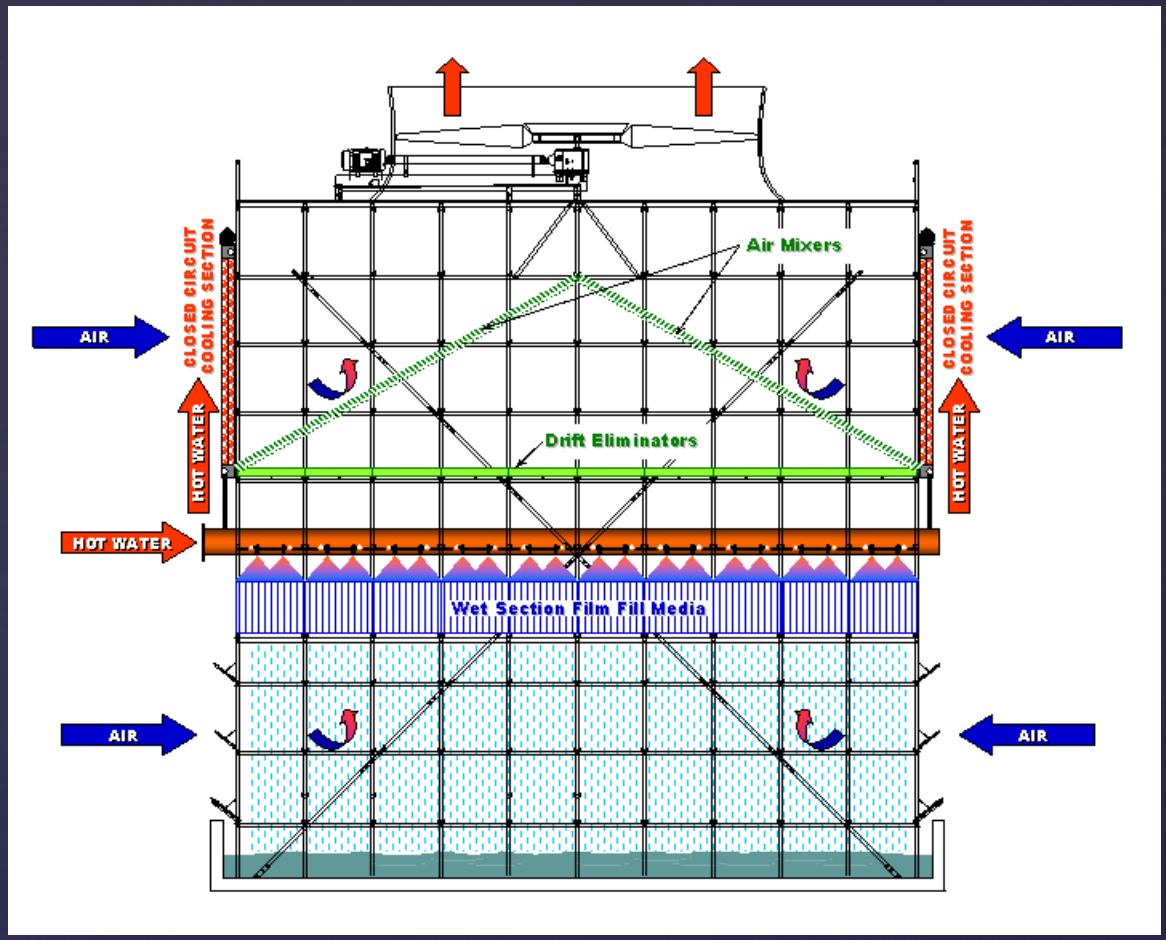


Water Consumption Example



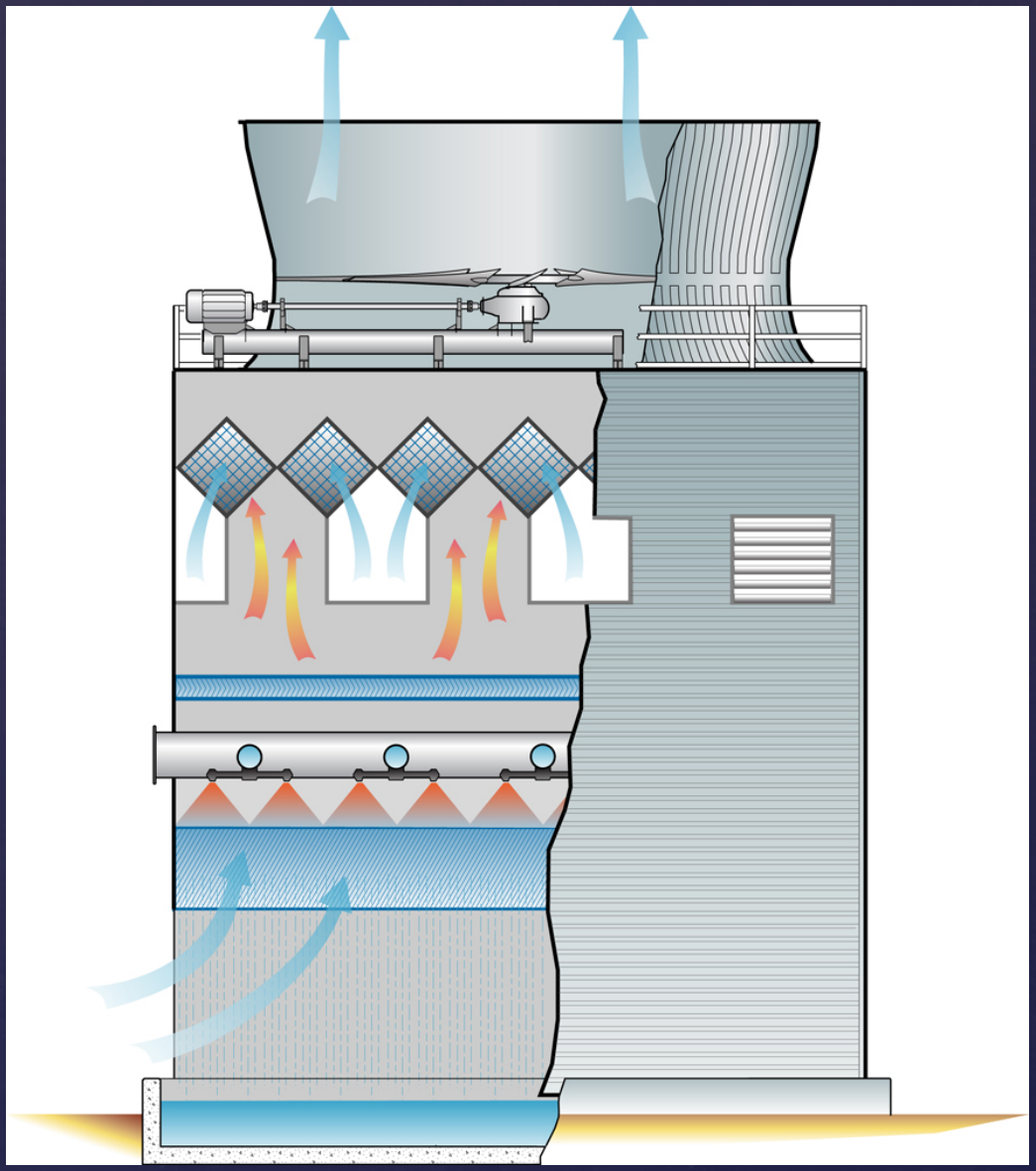
Water Consumption Example

Wet-Dry Cooling

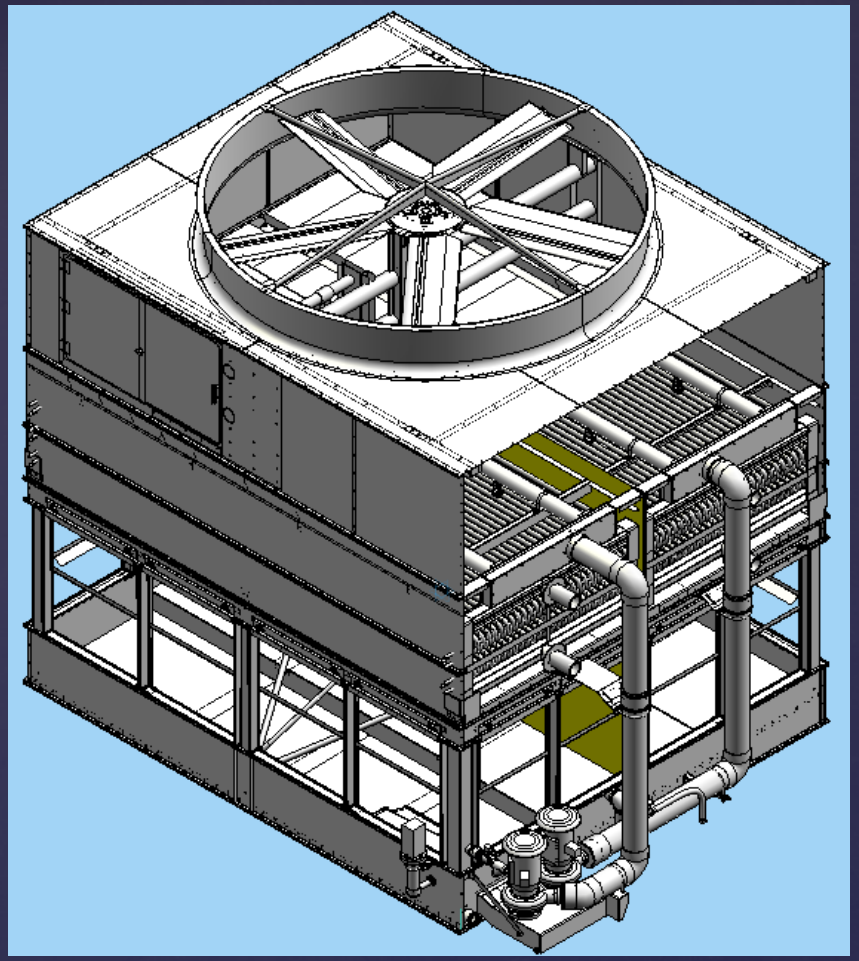

Air Mixers
CLOSED CIRCUIT COOLING SECTION
CLOSED CIRCUIT COOLING SECTION
AIR
AIR
HOT WATER
HOT WATER
Drift Eliminators
HOT WATER
Wet Section Film Fill Media
AIR
AIR

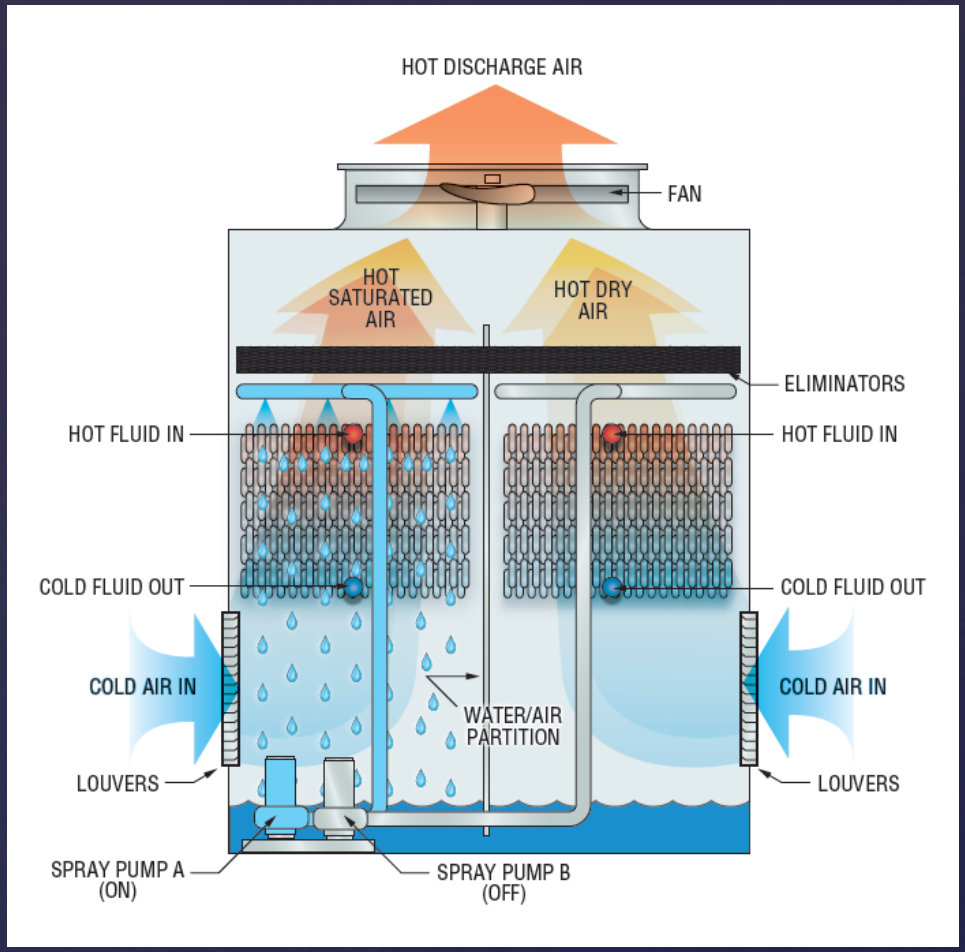
PPWD

Clear Sky

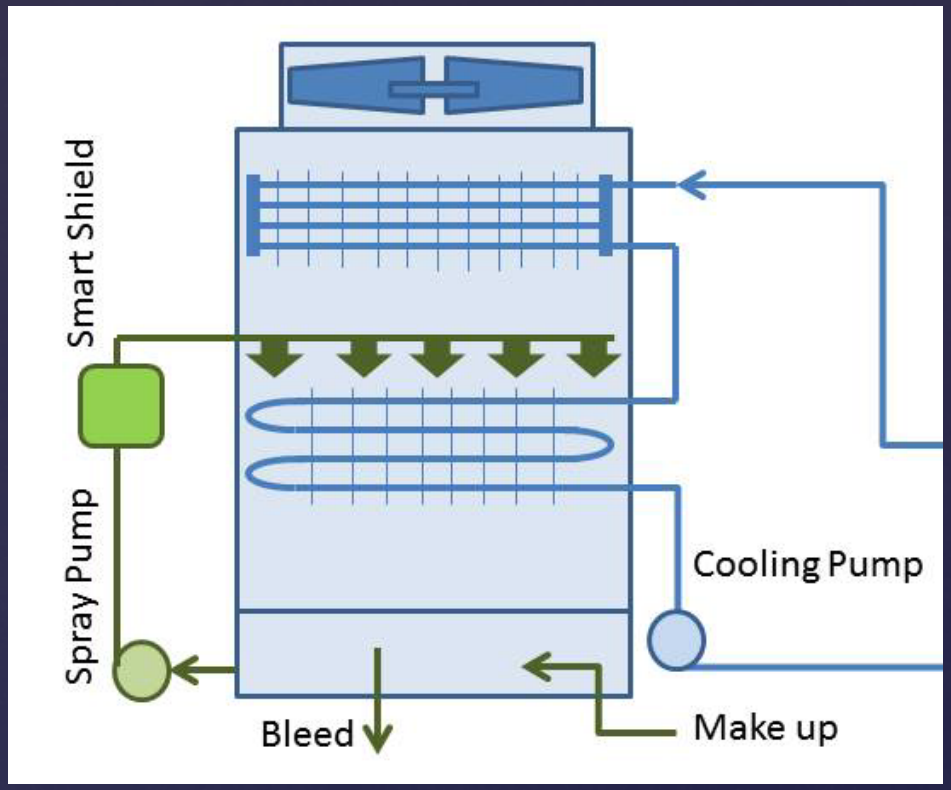


Courtesy: SPX Cooling Technologies

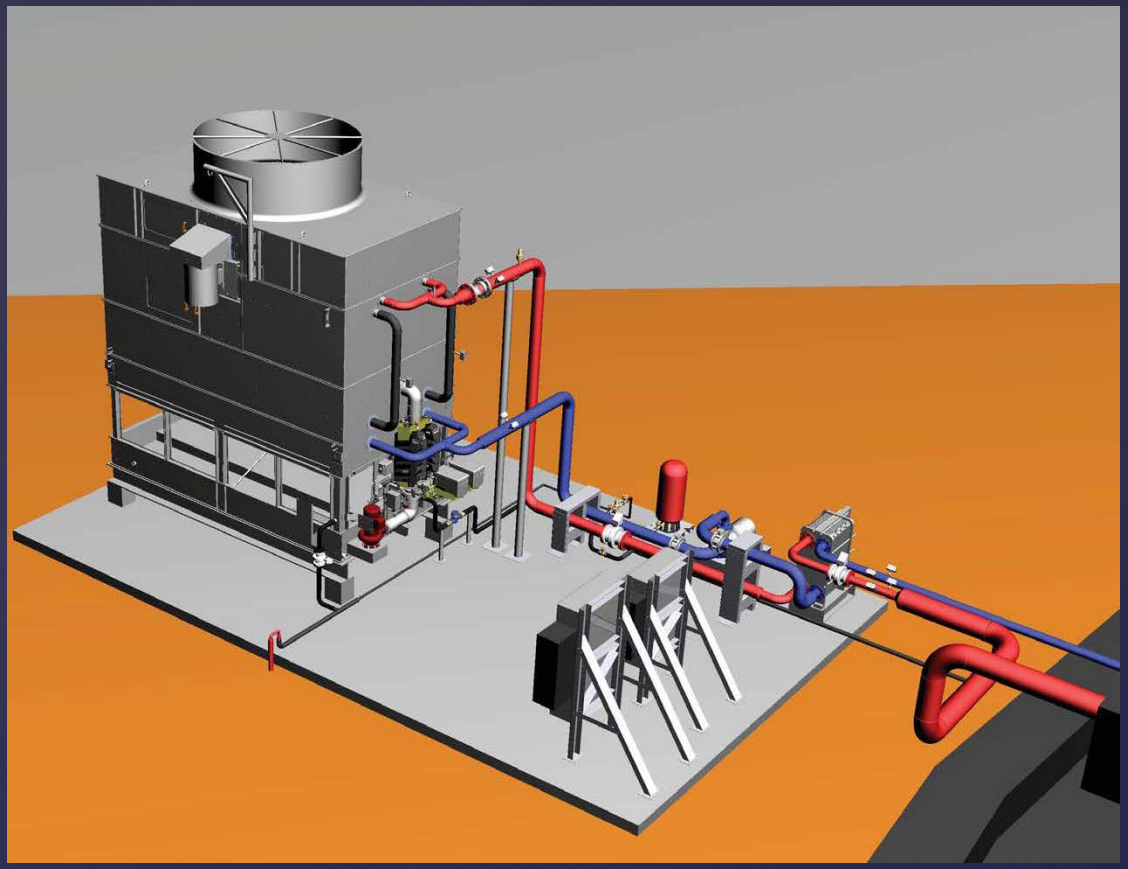




Closed Loop Dual Coil



Closed Loop WDC



EPRI Southern Co. WRC

Thank You!

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