Task 2. Overview – Details subject to change until full problem statement is published

2026

Power Plants: Recovering Water from Cooling Towers

Task Sponsored by Diamond Sponsor El Paso Electric Co. Charitable Foundation

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Introduction

Your team has the opportunity to design water-saving measures that could be used in power plants across the globe. Electricity generation requires substantial amounts of water – averaging about 11 thousand gallons of water per MWh across the U.S. [1]. Some power plants can be sited strategically near rivers, lakes, or the sea, where there is plenty of flowing water for steam generation and cooling. Afterwards, the water can be returned to that body of water. However, power plants that are sited away from readily accessed water (we will call them "inland sites") do not have this advantage. Their water resources are much more limited, warranting enhanced water conservation. This design challenge focuses on recovering and reusing water in evaporative (wet) cooling systems in inland areas where the need for water recovery is high.

Problem Statement (Summary - Subject to change)

Your team will research, evaluate, and design a cost-effective retro-fitted water-vapor recovery system for wet-cooling towers in inland areas that are challenged by water scarcity. Your solution should maintain the current energy efficiency of wet cooling towers and maximize water recovery while minimizing the cost of implementation of the retrofit design. You may model your solution after any power plant you select or use the data provided for El Paso Electric Company.

You may use any innovative means to reduce the volumes of water vapor that otherwise would escape to the atmosphere. In your system, as much water as possible shall be recovered and returned to the cooling tower's cold-water basin for re-use. Your team's design shall, at a minimum, maintain the existing water quality in the recirculating cold-water basin and shall maintain the current performance of cooling towers as well as the day-to-day operations at the plant.

As proof-of-concept for your design, your team shall build a bench-scale prototype that demonstrates cost-effective enhanced water recovery in cooling towers.

Background

Electric power generation accounts for approximately 3% of all freshwater consumption because water plays a vital role in power generation. The power provided by power plants comes from sources such as solar, wind, nuclear, or natural gas to boil water and produce steam. Steam drives turbines that generate electricity, and once the steam has passed through the turbines, it is condensed into hot water. At this point, inland power plants recycle that water to produce more steam. The water that condensed the steam is sent to the cooling towers where heat is removed so that it can be used again to condense steam

Definitions: Water Withdrawal vs. Consumption; Steam vs Water Vapor

For the purpose of this design challenge, we will define the following.

- *Water withdrawal:* water that is withdrawn from surface waters, groundwater, etc. for use in cooling towers.
- *Water consumption:* water lost during industrial processes.
- Steam: an aerosol of water droplets that are produced from boiling water. Steam will be at or above the boiling point.
- *Water vapor:* invisible molecules in the gas phase or visible clouds (a.k.a, "plumes") of water droplets that are produced when cool water vapor (as a gas) comes in contact with cooler air and condenses into small droplets.

Wet Cooling Systems (a.k.a. Mechanical Draft Cooling Towers)

This task focuses on the most widely used cooling technology for power plants – wet cooling towers – that rely on evaporation to remove heat from water. Explaining their popularity, evaporation is the most energy efficient way to cool water and wet cooling towers are the most cost-effective units to build. Note that power plant cooling systems—commonly referred to as cooling towers—are not always tower-shaped, but the term is used for historical reasons.

Numerous overviews of power plant cooling are available (e.g., [2, 3, 4], etc.). This task focuses on the subset of wet-cooling towers that transfer heat through fan-driven evaporation and forced convection. These are termed mechanical draft cooling towers (MDCTs). The purpose of the fans is two-fold: to facilitate evaporation as the water moves through the fill and to vent hot air and water vapor to the atmosphere [5]. Though not addressed here, the alternative to MDCTs is Natural Convection Wet Cooling Towers that do not use fans to drive convection.

The basic process flow of an MDCT system that incorporates water recycling is illustrated in Figure 1. In the condenser ①, flowing cold water cools the steam that has recently passed through the turbines. The water condenses the steam into hot water. The condensing water is sent to the MDCT ② where it travels through "fill" ③ that is usually made of polymer baffles. The fill increases the evaporation surface area. Large fans move air across the wet fill ④ facilitating evaporation processes that remove heat from the water. The fans also serve to vent hot air and water vapor produced by evaporation ⑤. The remaining cool water refills the cold-water basin ⑥ where it can be recycled; "make-up water" ⑦ is added to replace the water that is lost to evaporation, and finally, the process is repeated as the cooled water is returned to the condenser ⑧.

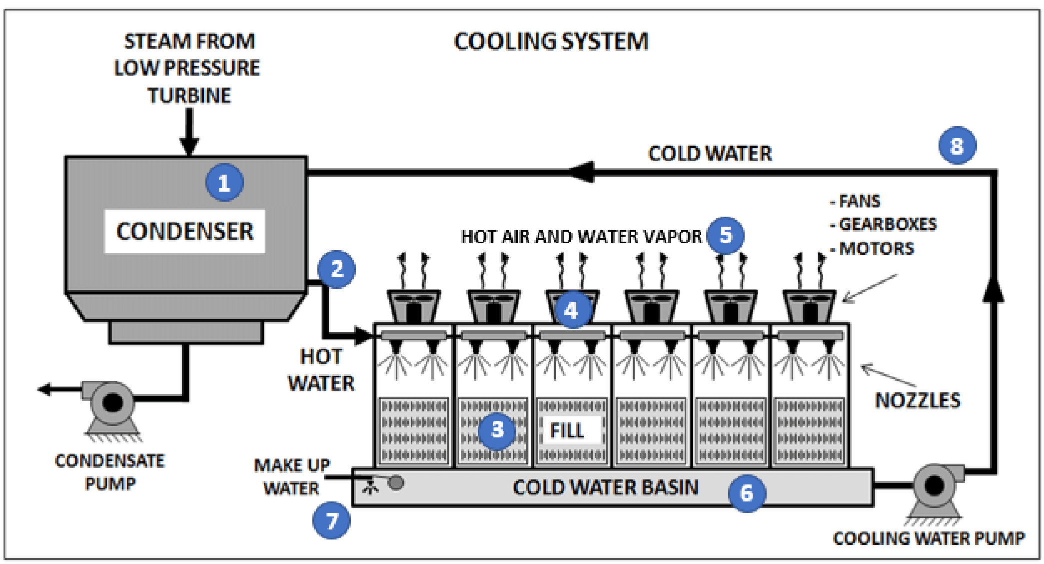

Fig. 1. Mechanical Draft Cooling Tower (MDCT) schematic.

Water recycling in wet cooling towers saves significant amounts of water for power plants, but MDCTs reportedly lose 55 – 85% of their water through evaporation, depending on the climate and cooling tower configuration. Although the percentage lost appears low, the volumes of water consumed by a single power plant can be 1,750 to 2,500 liters per kilowatt-hour (L/kWh) [6].

To put this in perspective, we shall refer to a model published on data.gov that predicts electricity consumption for U.S. cities. The average estimated electricity consumption rate for the cities with the 50 highest electricity usage rates in the U.S. can be calculated at 10,376,000 MWh/year per 1 million people [7]. Based on this average and the L/kWh expressed above, a plant that serves 1 million people could consume between 4 and 7 billion gal/yr. Although it is difficult to estimate how many inland cooling towers could benefit from your team's technology, in the U.S. alone, more than half of the inland coal and nuclear plants use evaporative (wet) cooling towers. As a result, inland wet cooling systems contribute to extremely high volumes of water loss within the U.S and worldwide.

Evaporation, as discussed above, is the main source of water loss, but other factors contribute to the problem. Although not explicitly a part of this task, the reader will likely come across references to additional sources of water loss such as "drift" (small amounts of water that can be carried off by wind) and "blowdown" (or "bleed-off") (replacing high TDS circulating water with "makeup" water that has a lower TDS (level of Total Dissolved Solids).

<u>Wet vs Dry Cooling Systems</u>

The greatest advantage of MDCTs is also their primary drawback: they rely on the most efficient means of removing heat: water evaporation. Although energy efficient, it leads to significant water loss. To counter this, some power plants are replacing some of their wet cooling towers with dry cooling units. For example, El Paso Electric Company in El Paso, TX, recently replaced three of their 60+ year-old cooling towers with one natural gas generation unit, the Newman 6, that uses dry cooling technology. They estimate that the 228 MW unit will save 600 million gallons of water per year.

Dry cooling depends on air to cool and condense the steam. In most dry cooling systems, hot water from the condenser flows through a closed-circuit heat exchanger, such as closed tubing, and cooler air is passed across it. Dry cooling systems can reduce water consumption by up to 90%, but there are significant drawbacks compared with wet cooling systems: 1) Their capital costs are much higher, 2) The air-to-water heat transfer rate is lower, often requiring auxiliary cooling fans and more cooling surface area – hence more infrastructure. In addition, as steam leaves the turbine, its temperature tends to be higher, leading to further reduction in energy efficiency [8].

As a result, there is a tradeoff between conserving water and maintaining energy efficiency when choosing between MDCTs and dry cooling systems. Moreover, for power plants that are already heavily invested in MDCT infrastructure, it may be difficult to justify a full transition to costly dry cooling systems that might result in higher electricity rates for customers.

Your team is invited to bridge the gap between the energy/water tradeoffs and help keep electricity rates low for customers by designing a retrofit system that will recover as much water as possible from MDCTs. Note, also, that reducing water withdrawal volumes will save money and offset costs of producing power.

<u>The Cost of Water</u>

The cost of water factors in significantly when evaluating the economics of installing and maintaining water conservation retrofits. Industrial (and other types of) water rates vary widely throughout the U.S. [9]. The Environmental Protection Agency's WaterSense program reported the average commercial cost of water in 2023 to be $5.64/1000 gal ($/kgal), and costs are expected to increase over time as water scarcity increases. The industry is recently seeing the cost of water range from below $3/1000 gal to $9/1000 gallons.

Climatic Conditions

A notable challenge in recovering water from water vapor in hot climates is condensing and capturing the water during hot weather. Teams are encouraged to consider technologies that would support water recovery throughout the year. However, even if marked efficiencies are only realized outside the summer months, considerable water savings could still be achieved over the course of a year.

Teams are advised to study the effect of climate on cooling performance and condensation rates since temperature, relative humidity, and air movement influence evaporation and condensation rates [10].

To conserve water in inland areas where surface water is not abundant, the cooled water is recycled by returning it through the system to generate more steam. The water-recycling process may be repeated up to five or six times, depending on the resulting water quality in the cold-water basin.

Controlling Plumes While Recovering Water

When the temperature of the water vapor leaving a cooling tower falls below the dew point, some of the water vapor will condense, developing plumes of water vapor (Fig. 2). As expected, this phenomenon is more common during cooler seasons.

Fig. 2. Example plumes rising from a 10-unit mechanical draft cooling tower. [11]

Visible plumes are often regulated by local governments, as they can cause issues: 1) They cause confusion among the public, who mistake the harmless vapor for pollution or mistake it for a fire and report it to a fire department. 2) The visible droplets can reduce visibility near roads and airport runways. 3) Winter plume drift, if it freezes on walkways or roads, could cause safety issues. 4) Elevated humidity near the cooling towers can accelerate corrosion of nearby equipment.

Thus, developing a means of capturing the water vapor for re-use in MDCTs would also support power plant operations indirectly by reducing regulatory oversight, increasing longevity of equipment, and improving public relations.

Case Study: El Paso Electric Co, El Paso, TX.

Teams may explore retrofit solutions to any inland power plant that is challenged by water scarcity. As a real-world example, El Paso Electric (EPE) operates in an inland water-stressed region. Their service area is approximately 10,000 square miles across West Texas and Southern New Mexico. Teams are encouraged to consider EPE's infrastructure and service area as a model for their solution but are welcome to apply their designs to other inland power facilities that are similarly challenged.

Due to local power needs, EPE is the largest water user in El Paso County, Texas, with a consumption rate of 2,048 L/Net MWh in 2024. This translates to EPE's total water use of approximately 28 trillion L/yr (or 7.5 billion gal/yr) [12]. Operating in an arid region lacking consistent surface waters (Fig. 2), EPE is continually working to reduce its water use.

While continuing to provide reliable power to the community, EPE has already successfully reduced water consumption by 300 L/Net MWh over the past two years. Current efforts toward this goal include recycling water in their cooling towers and implementing dry cooling technology in their most recently installed unit [12].

However, most of their cooling units (including the Rio Grande and Montana power stations, and all but one unit at the Newman Station) are MDCTs that have an expected remaining life of 10 to 20 years, making it most attractive to retrofit the units to maintain the plant's current energy efficiency while decreasing water consumption. Properly designed and implemented, reducing the cost of water would result in significant savings in operational costs that the company can pass along to their customers.

Fig. 2. Hueco Tanks, El Paso, TX. Illustrating the water-scarcity in the region. *Photo courtesy of John Lewis on Unsplash.*

<u>Retrofit Construction Time</u>

As teams are planning full-scale implementation of their designs, it is important to understand prototype testing and timelines at a power plant such as EPE. The best time to install and test a retrofit system is during a power plant's outage season. Most power plants schedule outage seasons, when they take a unit offline for maintenance and repairs. They typically select the outage season during the "shoulder months" of spring and fall, when electricity demand tends to be at a low, to minimize the impact on the customer.

For example, at EPE, they may take a unit offline for four consecutive months, such as October – February, leaving only four months to completely install and test a retrofit unit before it is fully online at the power station. This is a strict off-line schedule, since a unit cannot be taken offline longer than the outage season.

Teams should plan for complete installation and testing to comfortably fit within a four-month timeline, allowing a factor of safety for delays and troubleshooting.

<u>Opportunity for Innovation</u>

A primary challenge of this task is condensing the water vapor during hot summer weather. This is a particular challenge in arid regions. A successful solution may be able to recover some water vapor during the summer months, but your team may discover that there are optimal seasons for recovering water. Teams are encouraged to evaluate the amount (and cost) of water recovery over the course of a year. It is possible that your team will decide to operate water recovery technologies only during select times of the year.

By addressing water conservation of inherently energy efficient MDCTs through a retrofit design, continued energy efficiency of cooling towers in power generating stations can be supported without compromising current performance or building completely new infrastructure. Since MDCTs are so widely used, your team's design could recover millions of gallons of water in power plant cooling towers across the country. This, in turn, could result in keeping electricity costs low for customers since the water savings could significantly offset the cost of retrofit construction and installation.

Note that some companies are currently marketing retrofits intended to reduce cooling tower plumes [13, 14]. Some of these designs also recover water [15]. Your team's challenge is to look beyond existing technology and explore innovative, cost-effective ways to address these challenges.

Dates, Deadlines, FAQs (*dates subject to change—watch website FAQs*)

This Fall	Email us to reserve a spot for your team and get on the email list for this task. Registration is limited.
Weekly	Check FAQs weekly for updates: • Task-specific FAQs: 2026 Tasks/Task FAQs • General FAQs: 2026 General FAQs
November 1, 2025 - December 31, 2025	Early Bird Registration (discount applies)
December 1, 2025 – January 30, 2026	30% Project Review Due (or as arranged with WERC).
December 1, 2025 – February 16,2026	Mandatory On-demand Course: Preparing the Experimental Safety Plan. See website and Team Manual for information.
February 17, 2026	Final date to register a team w/o permission.
March 9 -13, 2026	Experimental Safety Plan (ESP) due to Juanita Miller. Include requests for chemicals, materials, etc.
April 2, 2026	Technical Report due
April 12 – 15, 2026	Contest in Las Cruces

Contacts:

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All other questions and concerns: Ginger Scarbrough, werc@nmsu.edu

References

[1] U.S. electric power sector continues water efficiency gains. June 2023. U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=56820

[2] Duvenhage, D.F. An Introduction to the Anatomy of Evaporative Cooling Towers. EPCM Holdings. No Date. An Introduction to the Anatomy of Evaporative Cooling Towers - EPCM

[3] current and future generation Cooling Power Plants. World Nuclear Association. 2018. https://world-nuclear.org/information-library/current-and-future-generation/cooling-power-plants

[4] How Do Cooling Towers Use Water. Infinite Cooling. 2024. https://www.infinite-cooling.com/post/how-do-cooling-towers-use-water#:~:text=As%20the%20hot%20water%20flows,the%20efficiency%20of%20the%20system.

[5] Souza, Gilberto & Murad, Carlos & Netto, Adherbal & Nabeta, Silvio & Melani, Arthur. 2017. Petri Net based reliability analysis of thermoelectric plant cooling tower. 10.26678/ABCM.COBEM2017.COB17-2203. https://www.researchgate.net/figure/Cooling-Tower-System_fig1_323203802

[6] Is the Cooling of Power Plants a Constraint on the Future of Nuclear Power? World Nuclear Association. 2020. Is the Cooling of Power Plants a Constraint on the Future of Nuclear Power? - World Nuclear Association

[7] City and Country Energy Profiles. Data.gov. https://catalog.data.gov/dataset/city-and-county-energy-profiles-60fbd/resource/a304bf4f-2984-436f-9edf-94093c04a5b1

[8] Some U.S. Electricity Generating Plants Use Dry Cooling. 2018. U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=36773

[9] Data and Information Used by WaterSense. Environmental Protection Agency. 2023. https://www.epa.gov/watersense/data-and-information-used-watersense#Cost%20of%20Water

[10] Cooling Tower Performance vs. Relative Humidity. BASIC THEORY AND PRACTICE. 2018. SPX COOLING TECHNOLOGIES, INC. https://spxcooling.com//wp-content/uploads/TR-020.pdf

[11] We're Pulling the Plug on Plume. Marley. 2025. https://spxcooling.com/wp-content/uploads/Clear-11.pdf

[12] El Paso Electric Company 2024 Corporate Sustainability Report. 2024. https://www.epelectric.com/energy-tech/sustainability/environmental/corporate-sustainability-reports/2024-corporate-sustainability-report

[13] Plume Abatement. 2025. Marley PPWD Hybrid Plume Abatement - SPX Cooling Towers

[14] WaterPanel™ | Plume Abatement. Infinite Cooling. 2025. https://www.infinite-cooling.com/plume-abatement

[15] Morris, B. Cooling Tower Plume: What Causes It? 2023. Construction and Commission.com-coolingtowerplume