Novel Dry Cooling Technology for Power Plants

SunShot Concentrating Solar Power Program Review 2013
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The International Center for Applied Energy Technology®

Overview

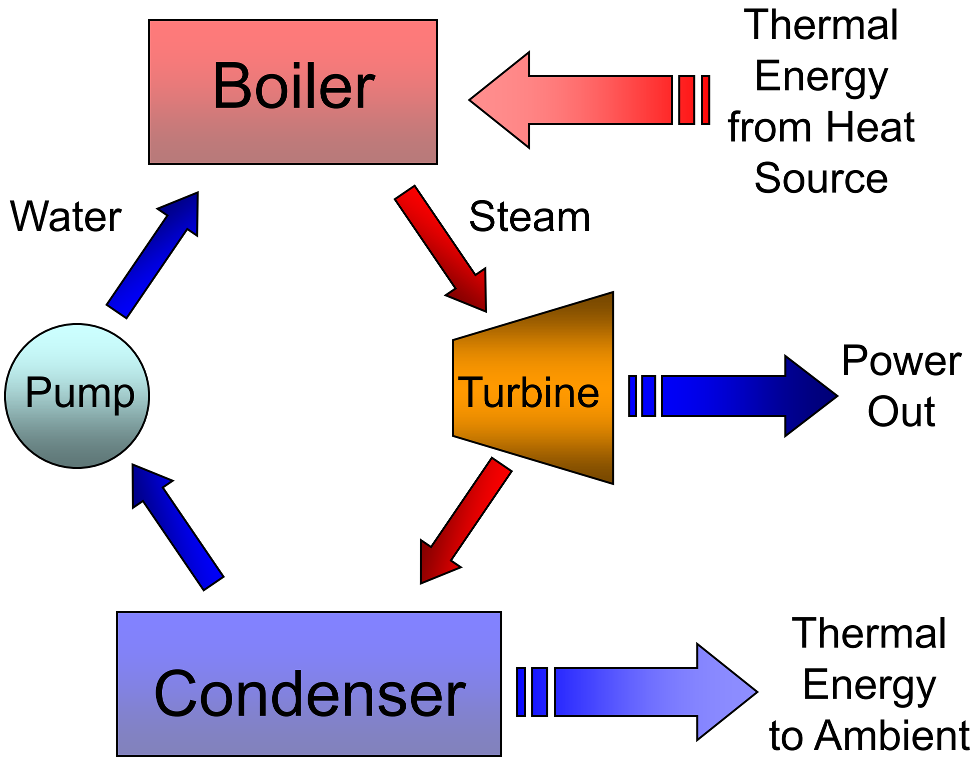
Presentation Outline

- Background
- Desiccant dry cooling (DDC) technology
- Previous analysis
- Conclusion

Project Information

- Initial development funded through the Department of Energy's National Energy Technology Laboratory (DOE-NETL) and the Wyoming Clean Coal Technology Fund.
- Current project sponsored under ARPA-E's OPEN 2012 program and started 4/1/2013.

Cooling Affects All Thermoelectric Generation



The most common methods for large-scale heat dissipation include:

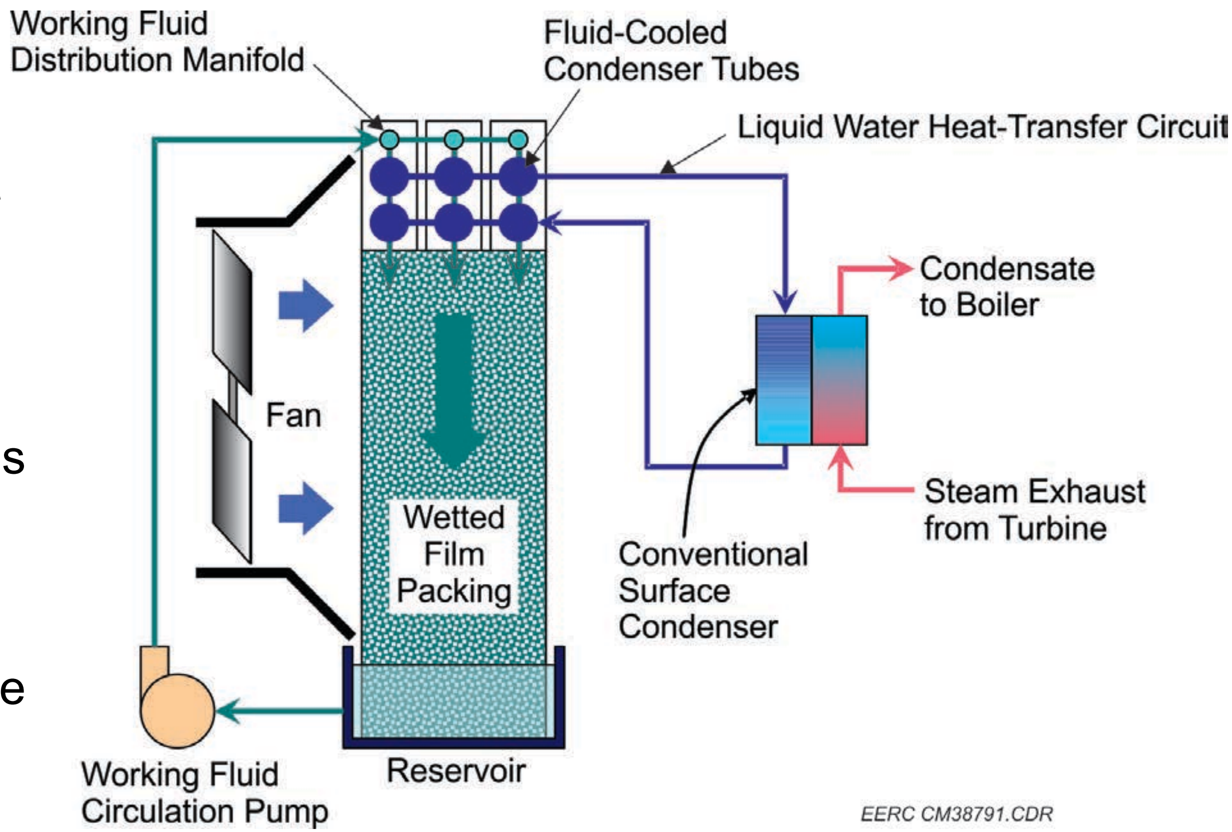
- Once-through wet cooling
- Wet recirculating (evaporative)
- Dry cooling with air

Air is the environmentally preferred, and sometimes the only, choice for power plant cooling. However, air cooling suffers from fundamental heat-transfer disadvantages:

$$Q = hA(T_{condenser} - T_{air})$$

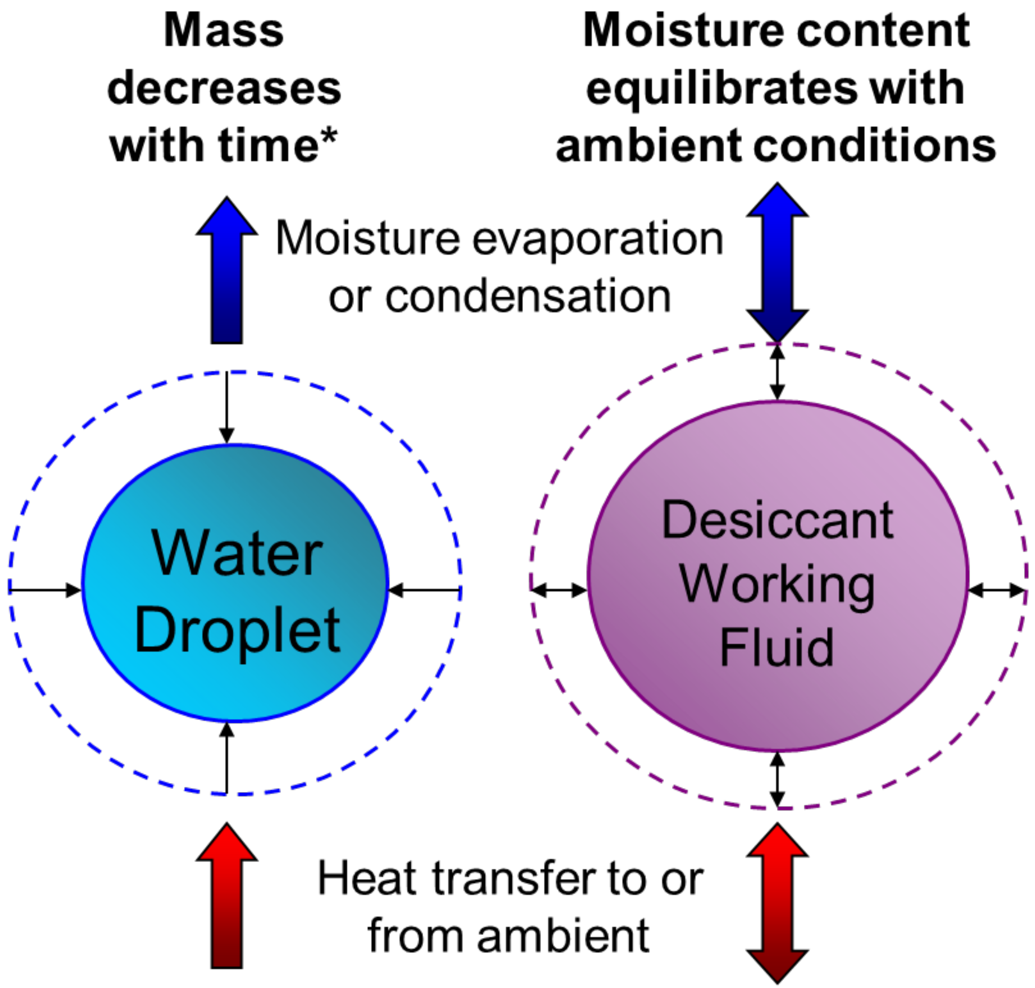
EERC Desiccant Dry Cooling

- The EERC's DDC concept uses a **hygroscopic** desiccant working fluid to dissipate thermal energy directly to the ambient air.
- DDC is intended to address the key shortcomings of conventional dry cooling, i.e., **high capital cost** and **degraded performance** during daytime temperature peaks.



Working Fluid Heat and Mass Transfer

- Unlike pure water, which typically undergoes constant evaporation, the desiccant will reach equilibrium and prevent a net loss of moisture.
- Compared to wet evaporative cooling, the net heat transfer is now sensible, but transient latent heat transfer is possible.
- While DDC circulates a liquid solution, there is no net water consumption, and the initial charge of working fluid is expected to last for the life of the system.



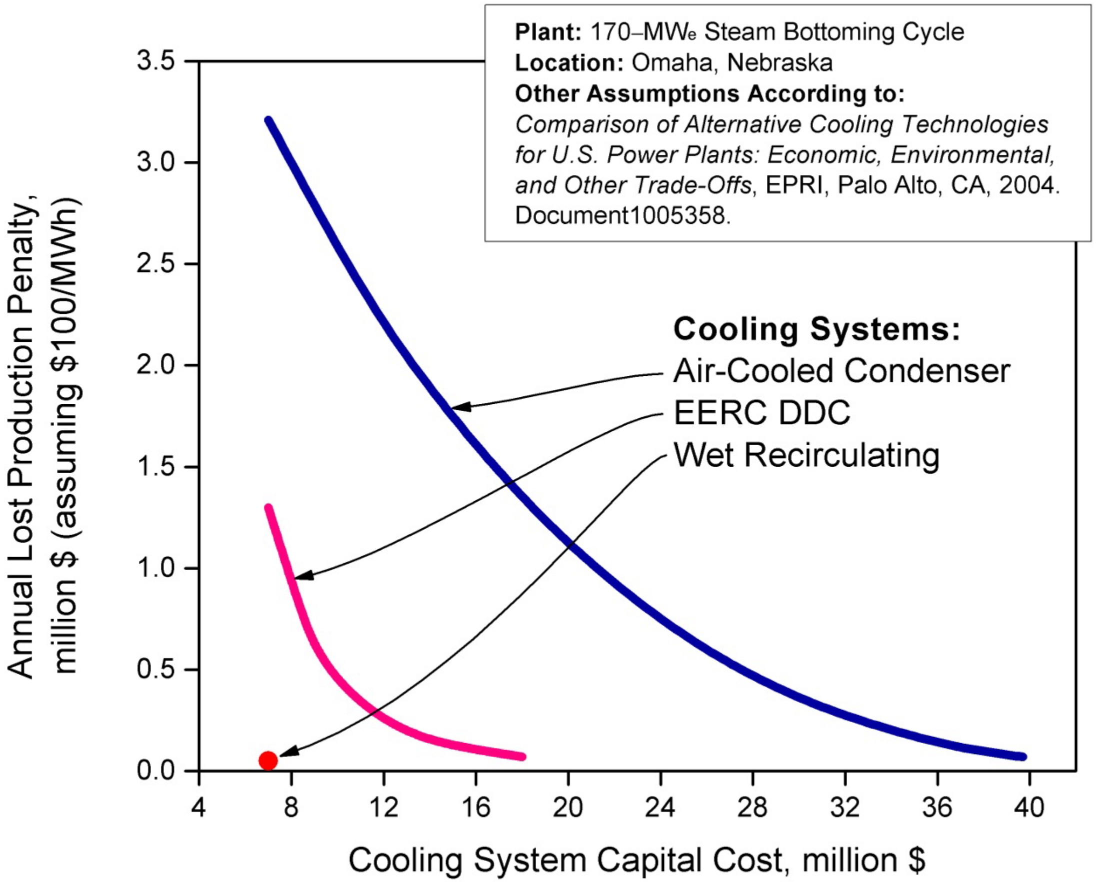
*Relative humidity <100%.

Direct Contact Heat Exchange

Direct contact heat exchange with ambient air has important implications for heat dissipation:

- Inexpensive, wetted packing structures can be used to create large heat-transfer surface areas.
- Heat transfer is partially driven by vapor pressure gradients, thereby increasing overall heat-transfer efficiency and potentially resulting in lower air-side pressure drop.
- Transient absorption and desorption of ambient moisture adds a component of latent heat transfer to the system that acts as integrated thermal storage.

Baseload Plant Case Study Results

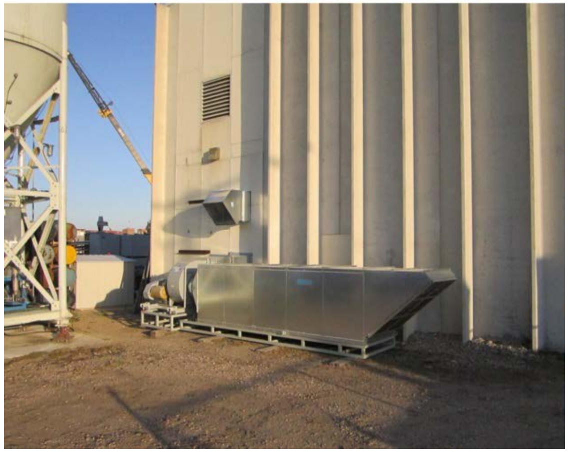


Case study results from initial project.

- Design considerations:
  - Wet or dry
  - Performance
  - Capital cost
- Where water is available, evaporative cooling will typically be the best design choice.
- For locations without adequate water, the EERC concept is estimated to offer improved cost and performance over an air-cooled condenser without compromising water consumption.

Test Facility

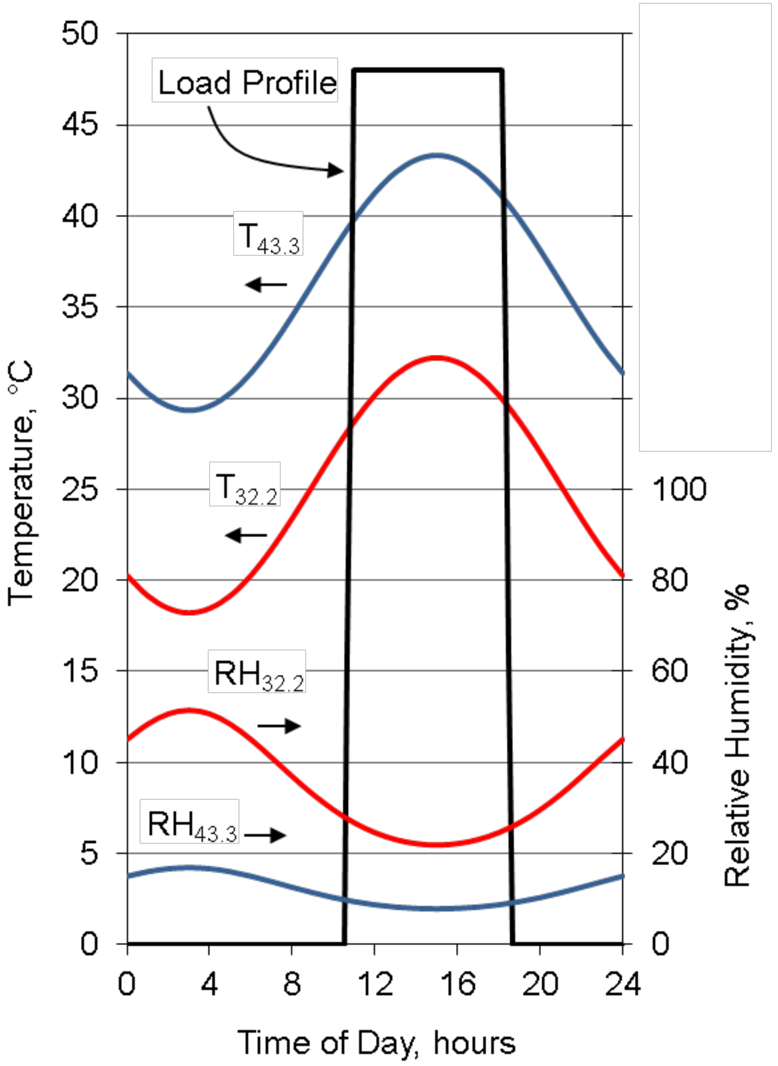
EERC CM42626.CDR



EERC CM43721.CDR

Solar Thermal Application

- For the solar application, the thermal storage aspect could be particularly useful.
- Hypothetical weather and thermal load profiles are used with the existing model to determine impacts to system design.
- Two design weather profiles were based on Barstow, CA:
  - Average summer high
  - Average annual maximum



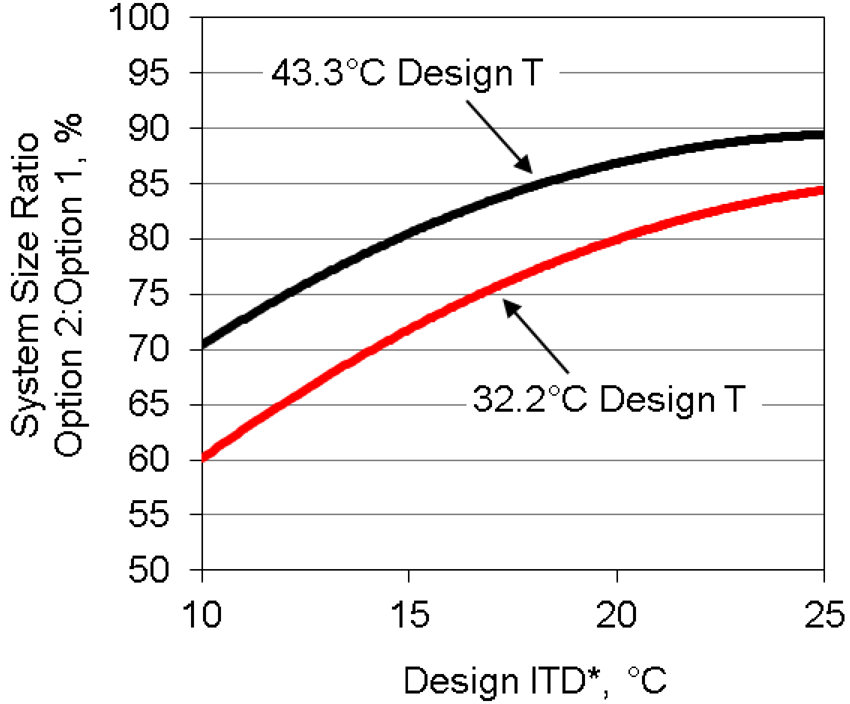
Modeled Operating Strategies

Two operating modes were evaluated:

Mode	Description
Option 1	Cooling system operates only when steam load is active: • Equivalent to conventional cooling system operation • Minimizes the contribution of thermal storage
Option 2	Cooling system continues to operate as long as heat is dissipated or until coolant equilibrates with ambient conditions: • Distributes heat rejection over a longer time period • Uses thermal storage—but not necessarily optimized

Comparison of Operating Modes

- In addition to the advantages highlighted during the baseload case study, further size reductions can be obtained for the solar thermal application by utilizing the latent thermal storage.
- Heat continues to be dissipated to the environment by bringing the working fluid into equilibrium, even after steam production stops.
- Depending on the design conditions, this study estimates that the cooling system can be sized 60%–90% of one that only operates during power-producing periods.



Initial temperature difference.

By using the storage aspect, initial capital expense can be offset with off-peak power consumption.

Summary

- The EERC's DDC system is a novel dry cooling technology currently under development. It is estimated to have a competitive advantage over conventional dry cooling options for large-scale heat dissipation.
- The unique cooling system design requirements and economics of solar thermal power plants may make them a more attractive application for DDC than the baseload application for which it was originally intended.
- The ARPA-E project objective is to develop specialized heat-exchange equipment specifically for use with DDC in order to meet specified performance and cost targets.

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