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Evaluating the Effect of Aqueous Calcium Chloride Desiccant on Cooling Tower Performance in a Heat-Integrated Post-Combustion CO_2 Capture System

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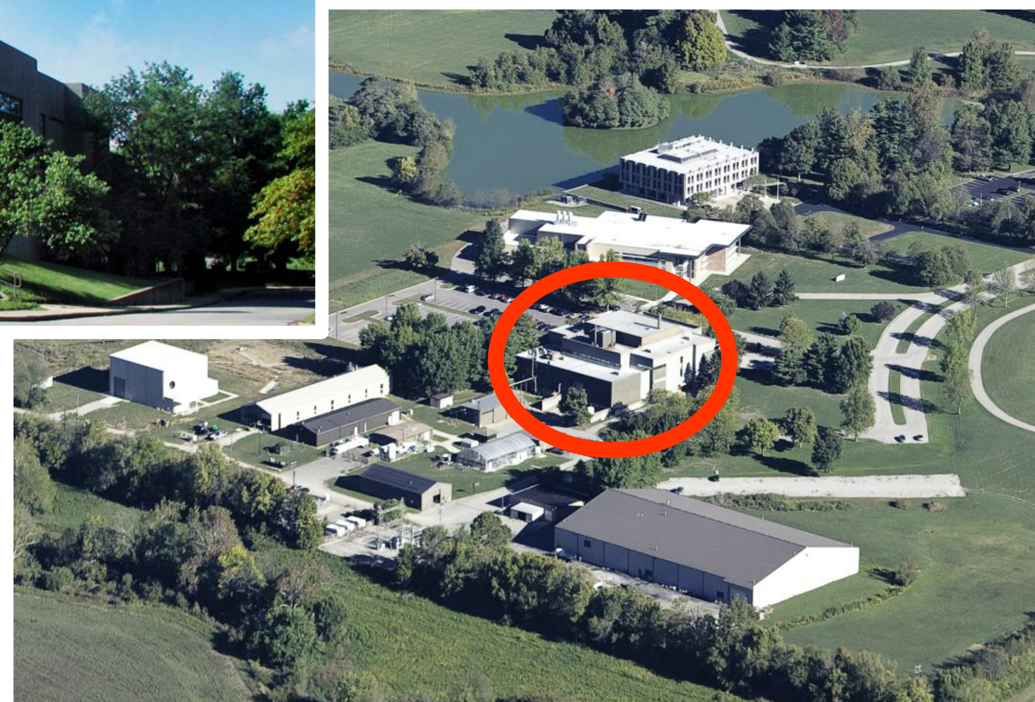

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Power Generation and Utility Fuels Group

Using Fossil Resources to Produce Clean Electricity

Post-Combustion CO_2 Capture	Solvent Development	Chemical Looping	Water Treatment	Corrosion
Process Integration and Scale-Up	Process Controls	Electro-chemistry	Membrane Separations	Analytical Methods Development

- About 30 researchers (engineers, scientists, technicians and students)
- 5 active projects sponsored by U.S. DOE and 2 active projects sponsored by industrial consortia
- 10-18 peer reviewed publications, annually
- 5-7 invention disclosures, annually
- 5-10 project proposal submitted, annually

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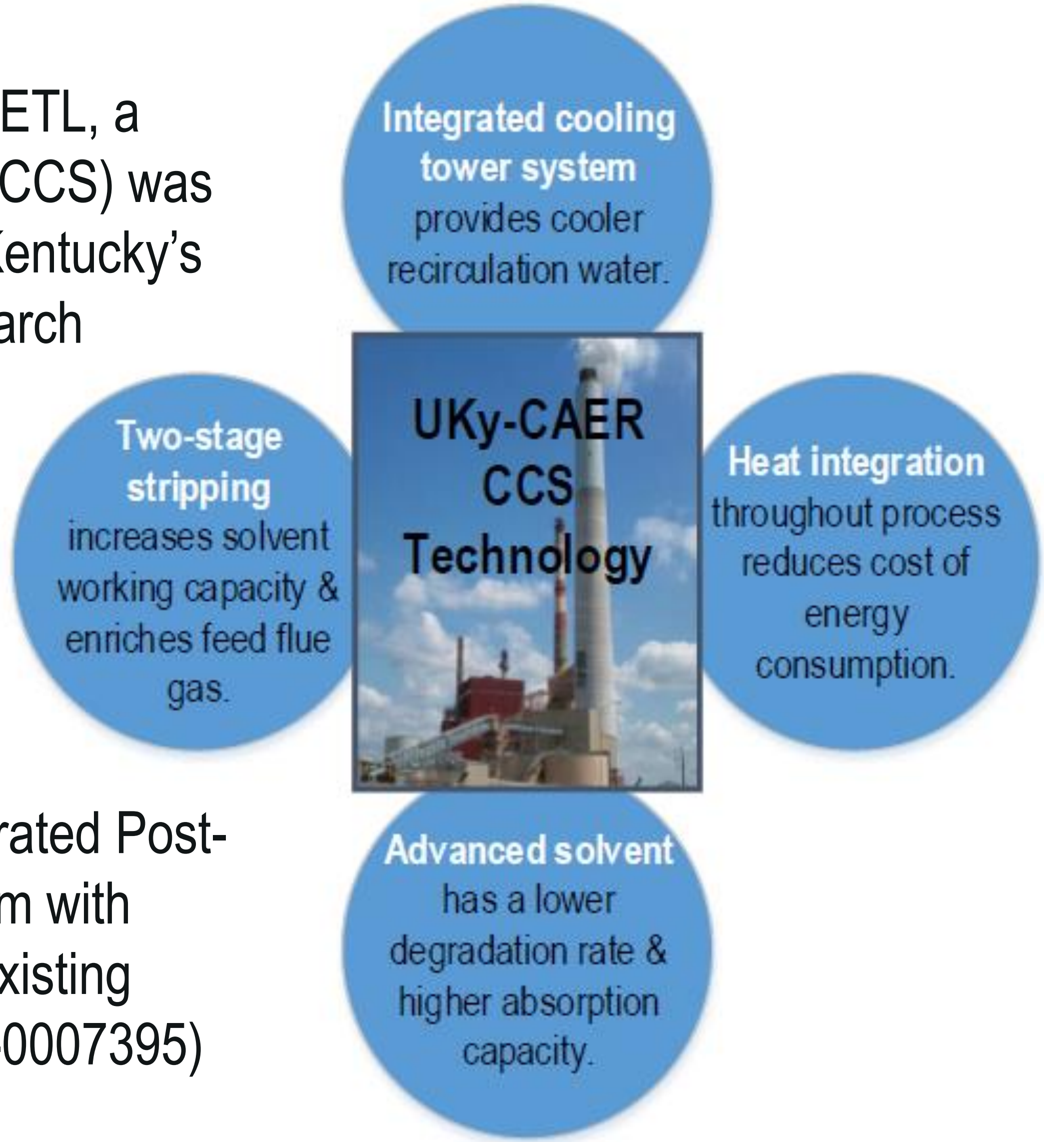
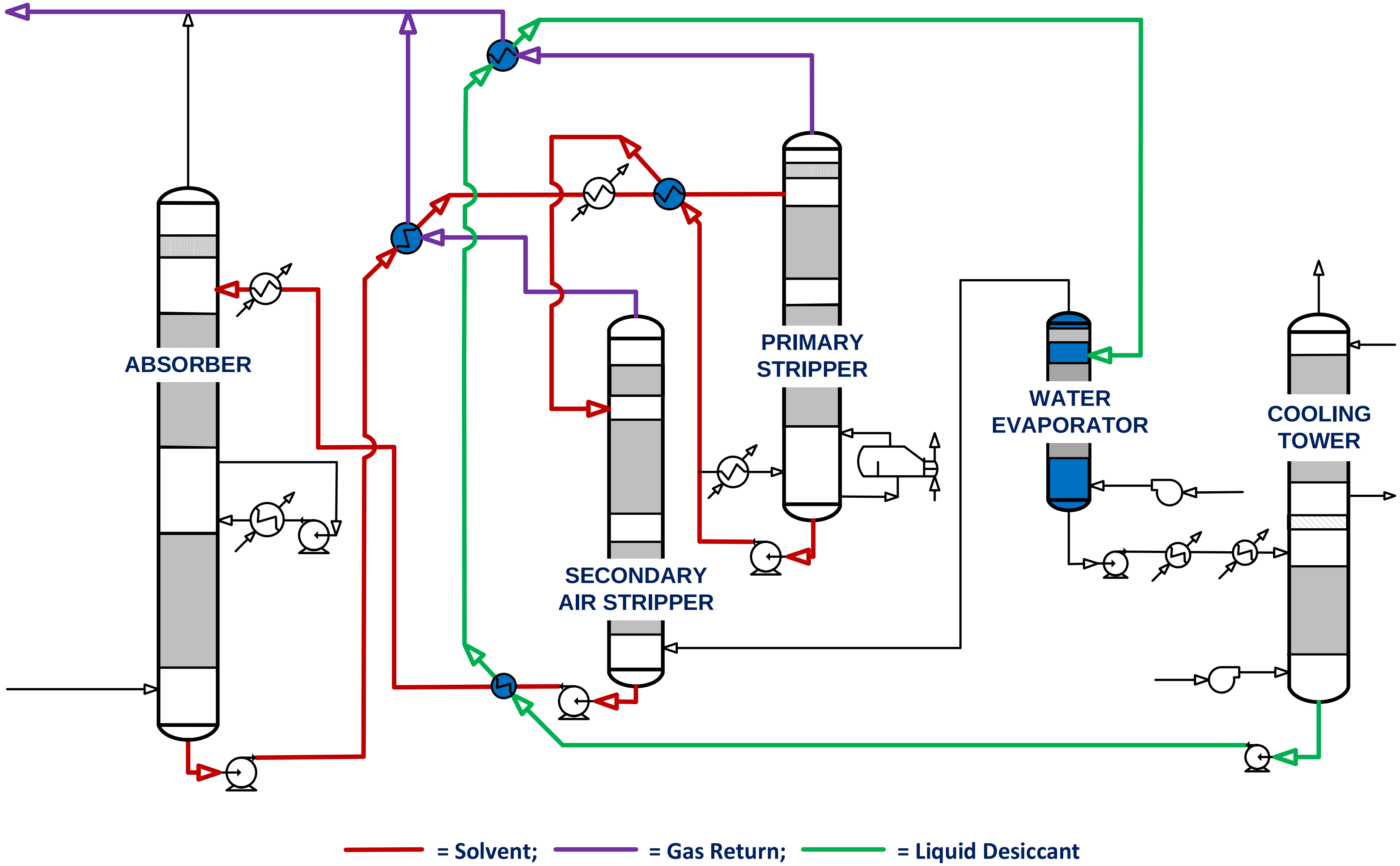
Carbon Capture Project Background

Primarily funded by U.S. DOE NETL, a 0.7 MWe CO_2 Capture System (CCS) was developed by the University of Kentucky's Center for Applied Energy Research (UKy- CAER),
installed at Kentucky Utilities E.W. Brown Generation Station and evaluated for overall plant efficiency.



Title: Application of a Heat Integrated Post-Combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant (DE-FE-0007395)

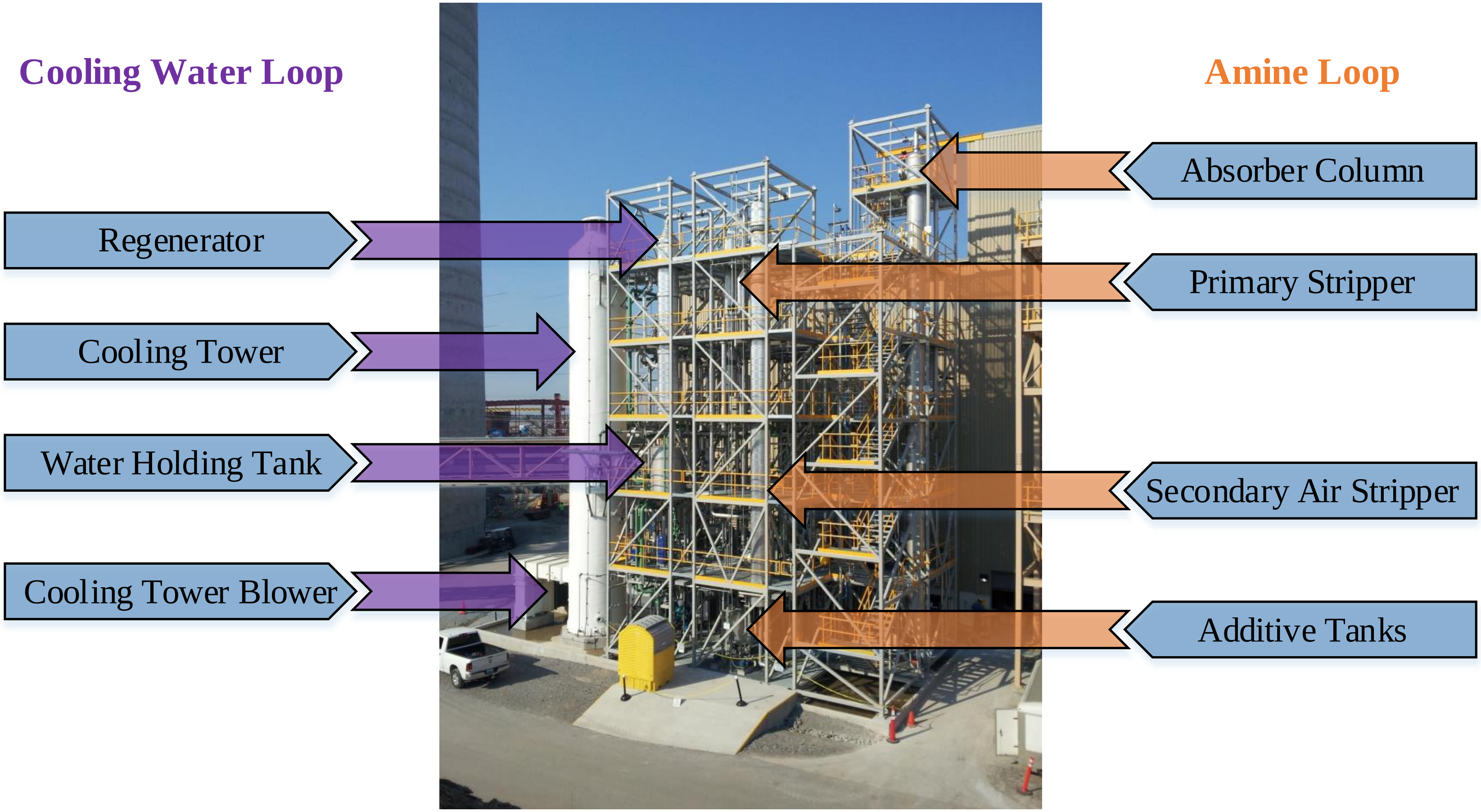
Benefits Realized in UKy-CAER CCS Technology



BENEFITS: 1) recovers waste energy, **2)** enhances CO_2 removal, **3)** improves commercial-scale turbine efficiency, **4)** reduces fresh water requirement

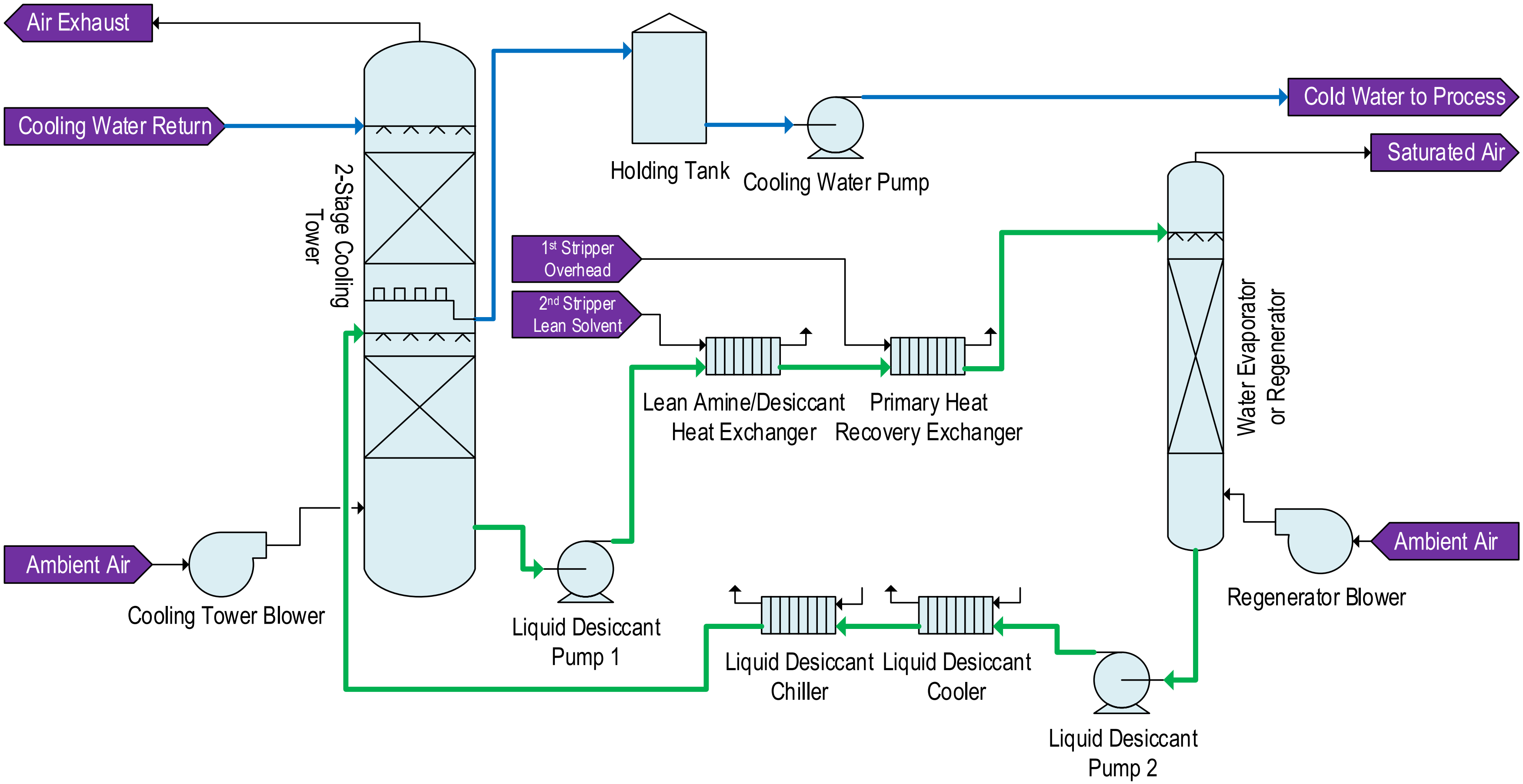
0.7 MWe Carbon Capture System

Application of a Heat Integrated Post-Combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant (DE-FE-0007395)



Small Pilot Scale CO_2 Capture Unit at E.W. Brown Generating Station in Harrodsburg, KY

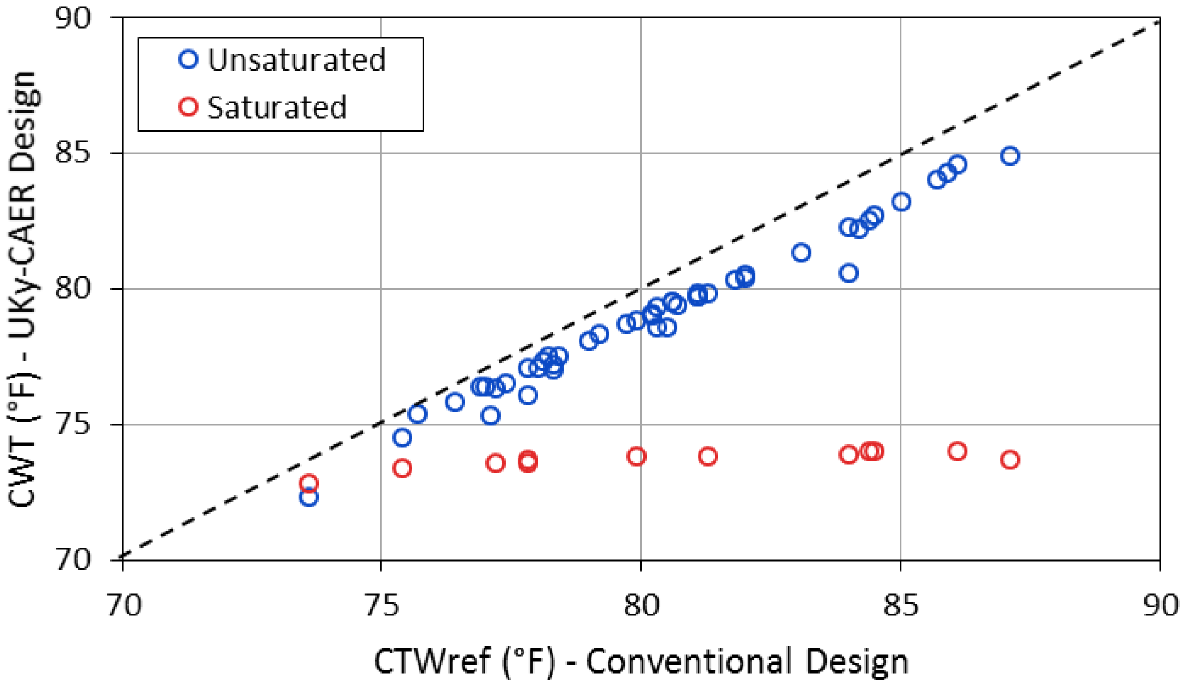
Heat-integrated Liquid Desiccant Loop and Cooling Tower



This process reduces the air relative humidity and wet bulb temperature (T_{wb}) in the top section, resulting in a lower cooling water temperature than otherwise plausible.

Cooling Tower Preliminary Simulation

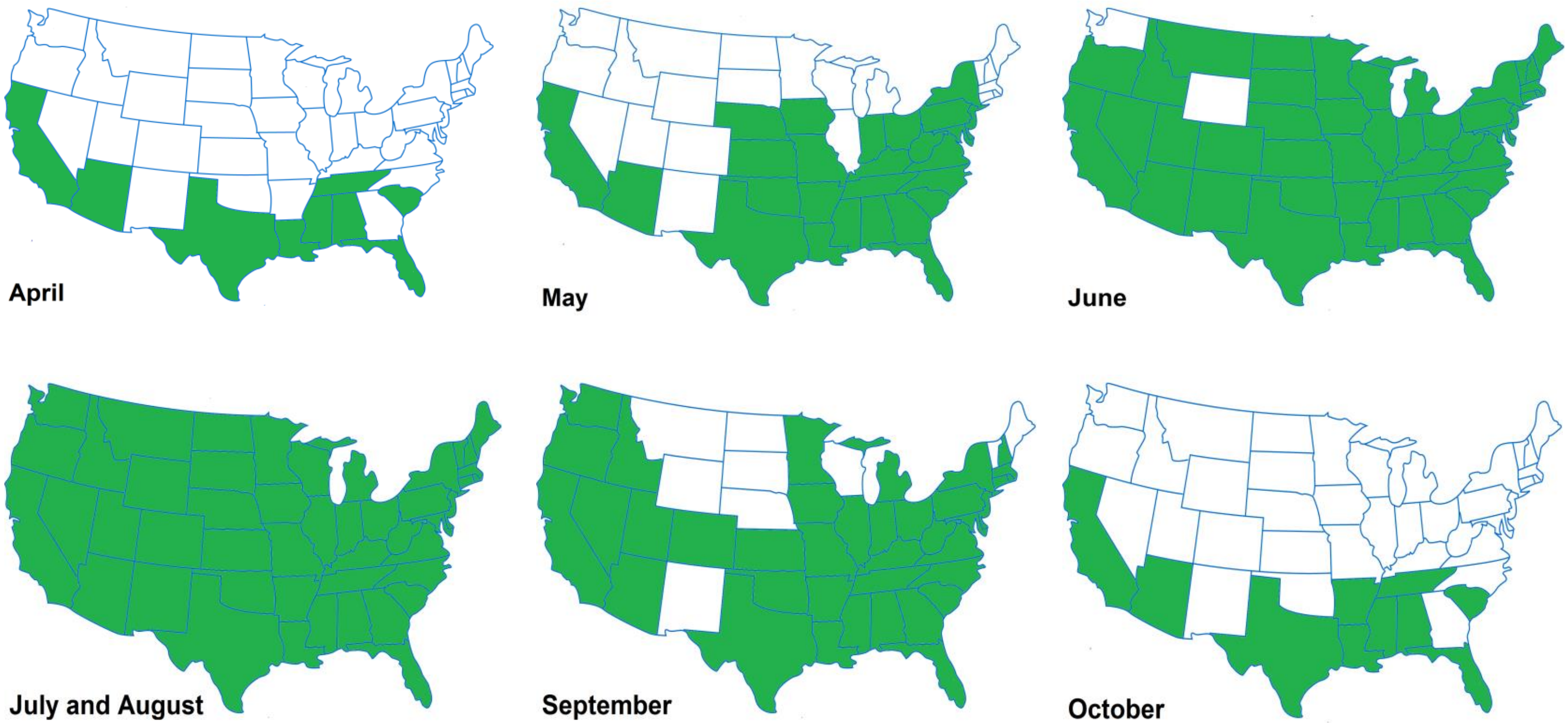
- Model suggested a T_{wb} depression of 3-7 degrees may be observed
- Simulations showed increased performance of the liquid desiccant loop as the CTWref increases above 72°F, achieving as much as a 12 degree difference in the cooling water exit temperature over the reference design



Simulated Cooling Tower Water Exit Temperatures in August for the UKy-CAER Modified and Traditional Cooling Tower Designs

Source: Version 8.2, Aspen Technology, Inc.

Sensitivity Study

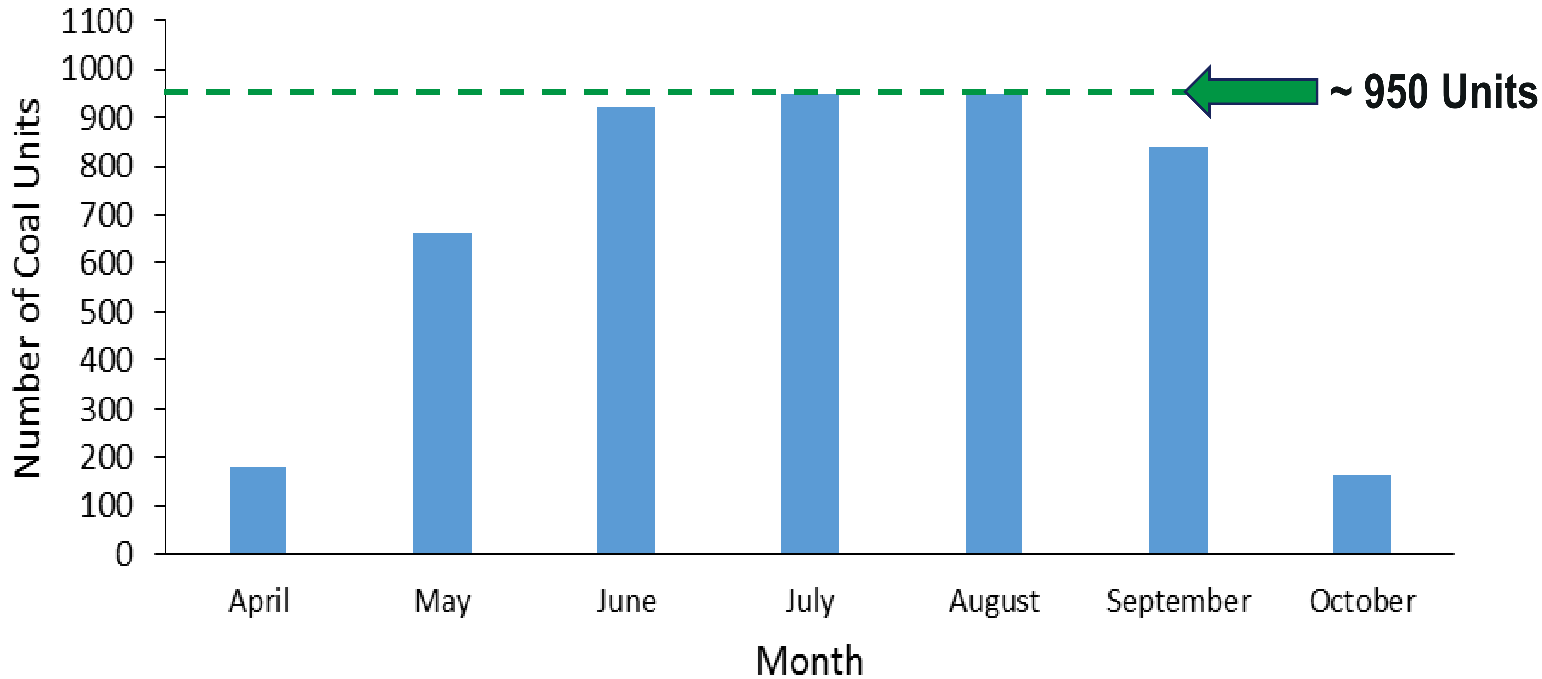


States in the Continental United States with Average, Monthly Weather Conditions in which a Liquid Desiccant Air Drying System Will Provide Additional Cooling

- Operation of a liquid desiccant air drying system will allow for increased efficiency in warm-weather months that are typical throughout the eastern and mid-western United States, and year-around in southern United States

Source: www.usclimatedata.com & www.currentresults.com

Application Study



Number of Coal-fired Units in the Continental United States with a CWTref Greater Than 72°F

- From May-September, ~600-950 coal-fired units in the continental United States may benefit from the liquid desiccant air drying system

Source: www.eia.gov/coal/data.cfm

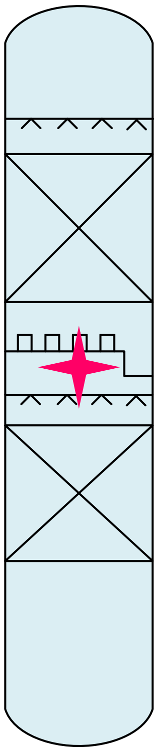
Experimental Methods

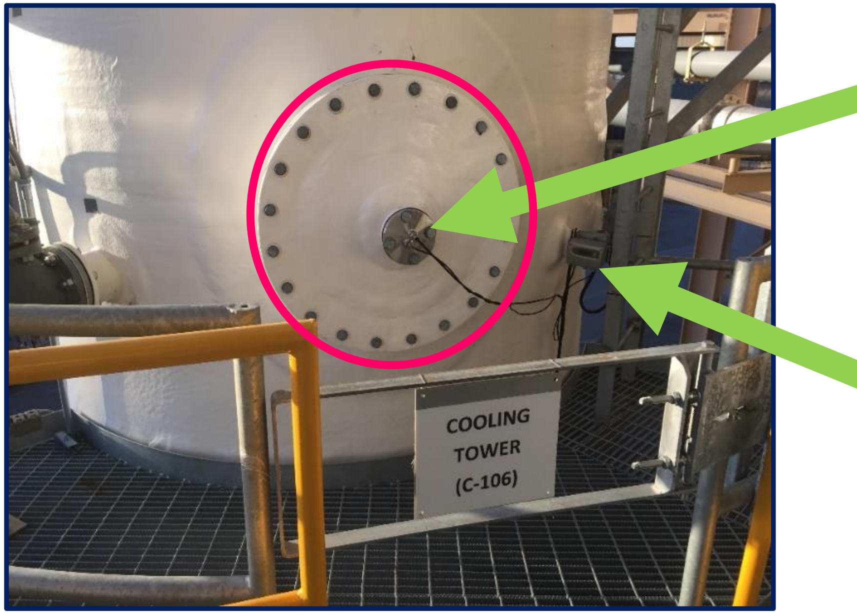
Elektronik EE33-J Probe Set:

- ❑ Evaporates condensation in high humidity environments
- ❑ Protects the humidity sensor from calcium chloride contamination with PTFE SS filter

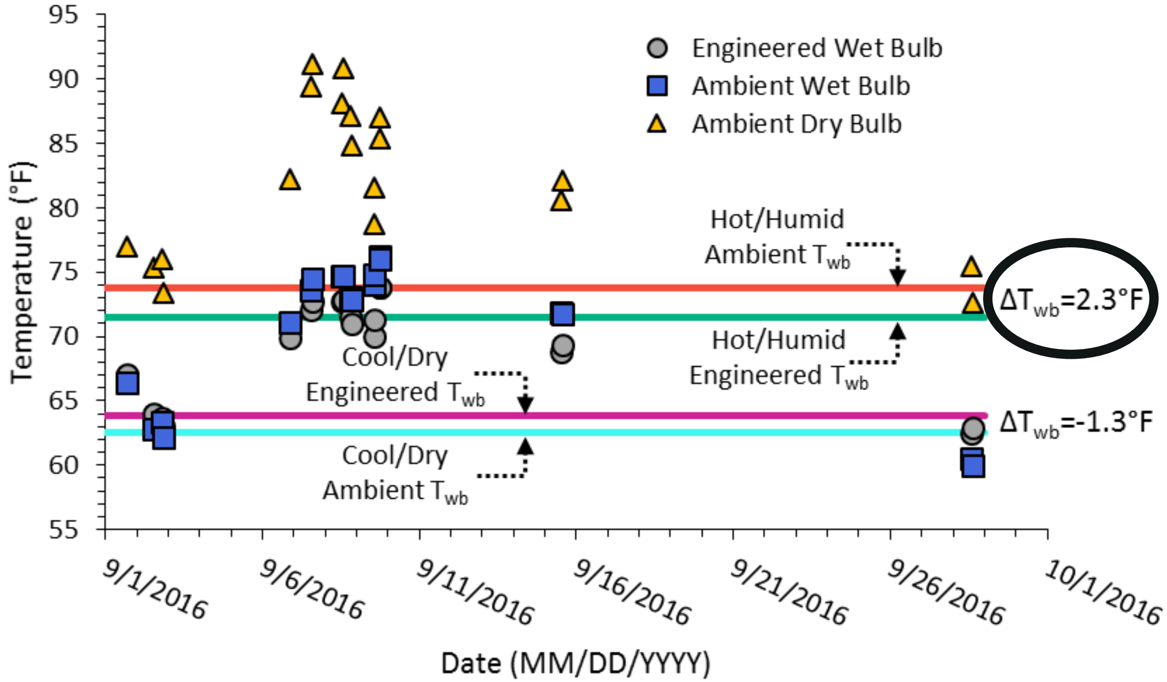
Concept Validation:

- ❑ Regenerator Air = 300 ACFM
- ❑ Cooling Tower Air = 15,000-28,000 SCFM
- ❑ Liquid Desiccant = 40-60 GPM
- ❑ Brine Concentration = 30-36 wt.%
- ❑ 1 Hour Periods of 90% CO_2 Capture





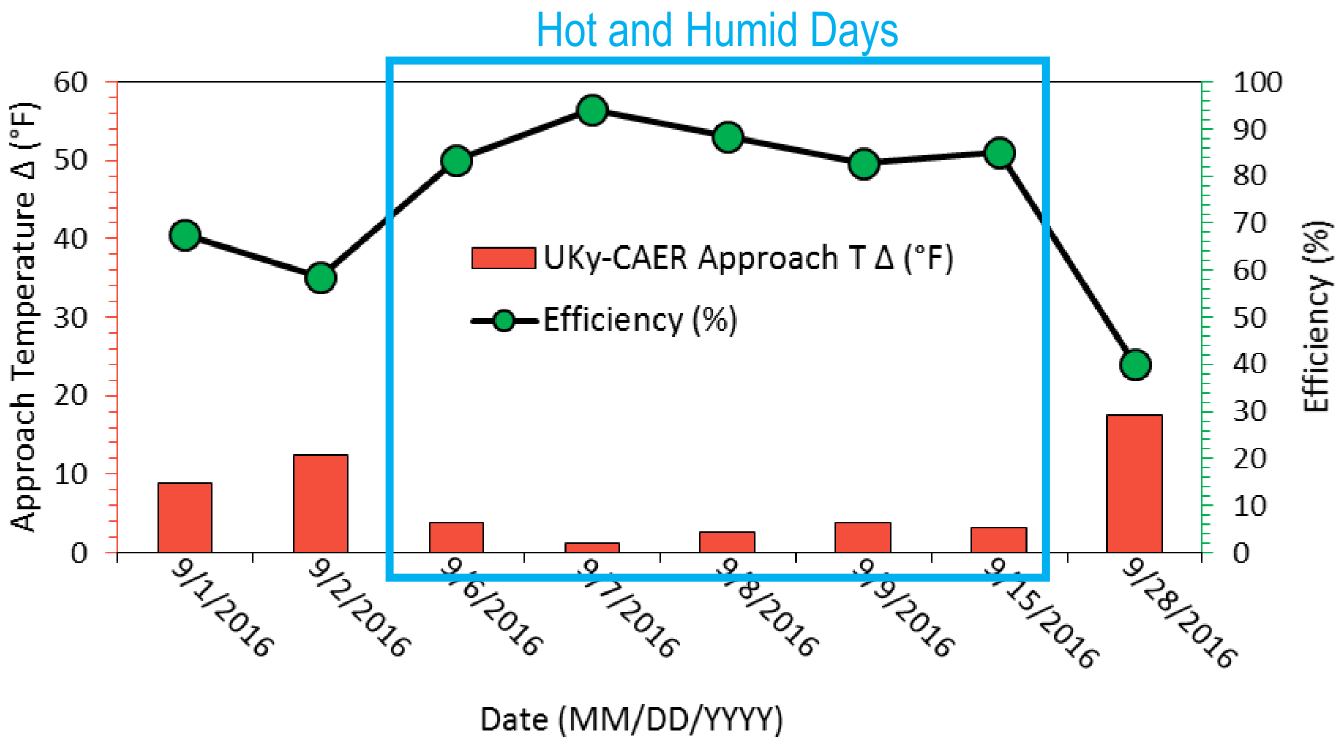
Parametric Campaign Results



Ambient T_{db}, Ambient T_{wb}, and Engineered T_{wb} from September 2016 UKy-CAER Parametric Tests

- T_{wb} was reduced by ~2.3°F with desiccant application, confirming design effectiveness
- Humidity was found to increase after energizing the desiccant loop on relatively cool, dry days, suggesting desiccant solution evaporation rate may exceed the absorption rate

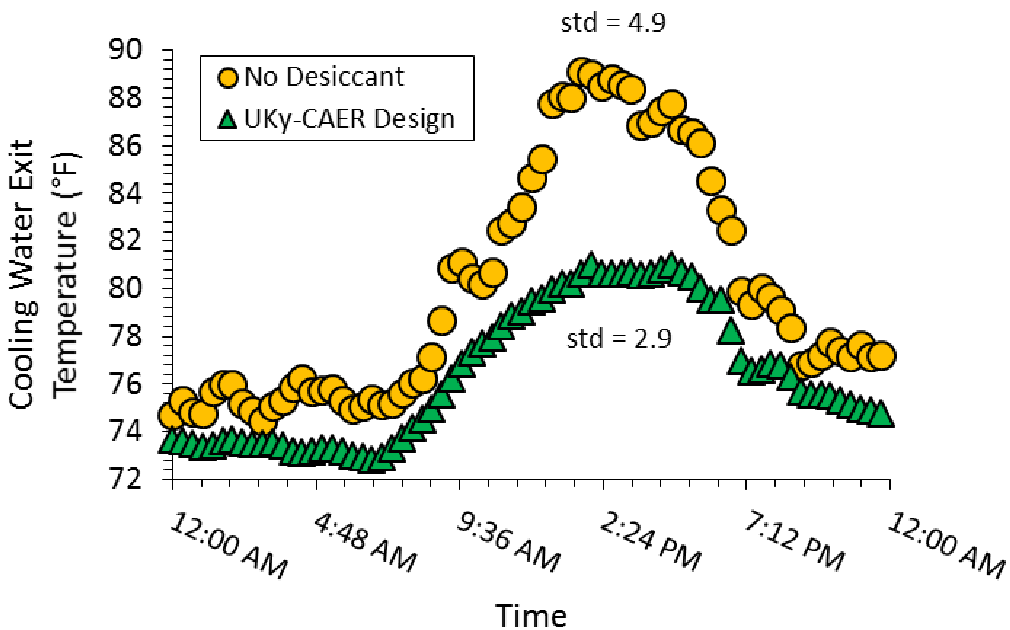
Parametric Campaign Results



Cooling Tower Approach Temperature Differences and Efficiencies from September 2016 UKy-CAER Parametric Tests

- Cooling tower performance improved on hot and humid environment days
- Energy needed to drive the thermal regeneration of the brine was within the inventory of available waste heat

Increased Stability of Cooling Water Exit Temperature



Cooling Water Exit Temperature with Liquid Desiccant Application in Comparison to the Conventional Design

- Absorption process may dampen temperature variability of inlet air, and thus, increase water exit temperature predictability
- Dehumidification process may help maintain the absorber temperature profile at the design condition
- Accurate estimations of turbine and condenser design specifications will result in a reliable and economic process

Conclusions

1) Recover Waste Energy →	Captured heat to recover solvent capacity in 2-stage stripping process, maintaining 90% capture without process manipulation
2) Reduce the Air Wet Bulb Temperature →	Observed wet bulb temperature drop, and competitive performance results on hot, humid days
3) Reduce Fresh Water Usage →	Solvent concentration and process levels maintained with controlled thermal input via regeneration process

Next Objectives

- Scale-up the unique UKy-CAER CO_2 Capture Process to 10 MWe post-combustion CO_2 capture system, to be located at LG&E Trimble County Power Plant near Bedford, KY
- Provide scale-up data, and design and operational information for commercial-scale deployment assessment

Acknowledgements

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