

New Cooling Technologies and Strategies

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University of California, Davis
WCEC
WESTERN COOLING
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RESEARCH • INNOVATION • PARTNERSHIP

Emerging Technologies for Cooling in the West

- **Existing Residential**

- Hot Dry Air Conditioners

- Existing equipment
- High-EER

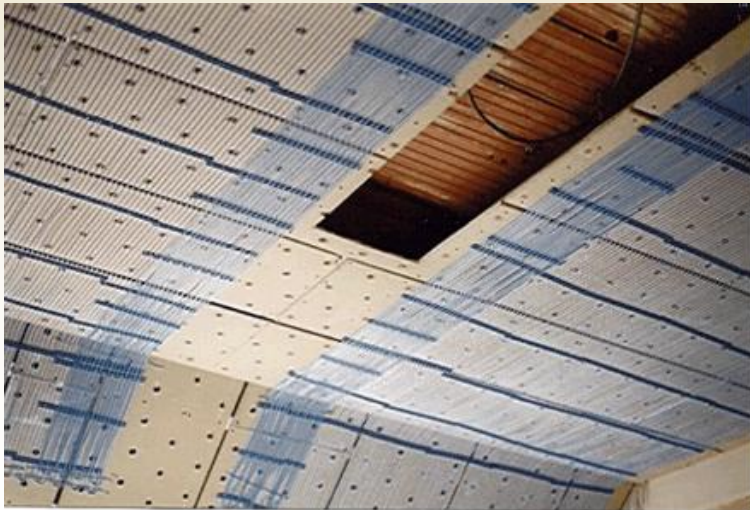
- Evaporative Condensers

- Hybrid evaporative/vapor-compression equipment



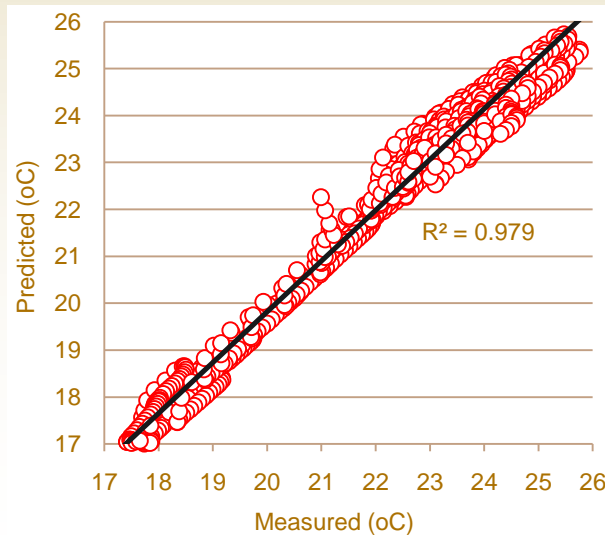
Emerging Technologies for Cooling in the West

- Residential New Construction
 - Radiant Cooling
 - Chilled-water storage
 - Water capture/re-use
 - Hybrid evap/vapor-compression



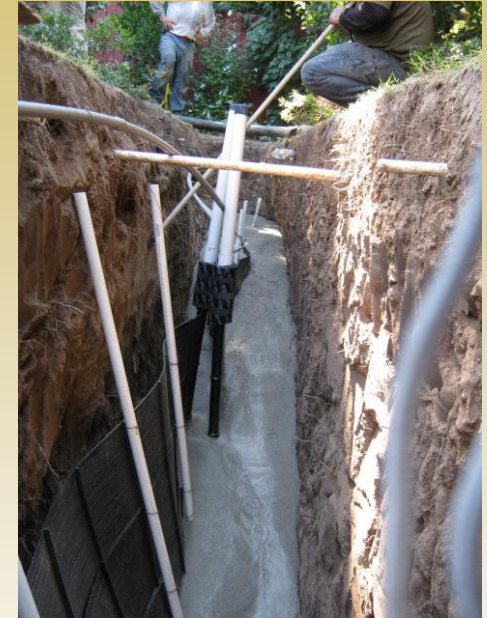
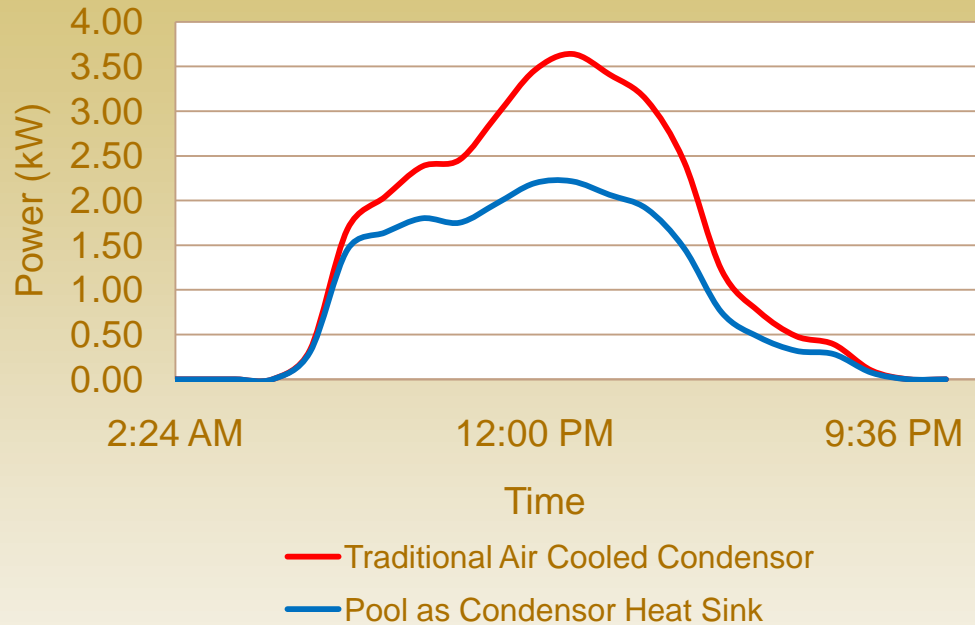
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New /Existing Residential – Swimming Pool Heat Sink



— Predicted — Measured

New /Existing Residential – Swimming Pool Heat Sink



Emerging Technologies for Cooling in the West

Existing Commercial

- RTUs = 70% of Market
- **Replacement**
 - Western Cooling Challenge
- **Retrofit**
 - Indirect Evaporative Outdoor Air Cooling
 - Evaporative Pre-Cooling of Condenser Air
 - Condensate Evaporation (Wickool)



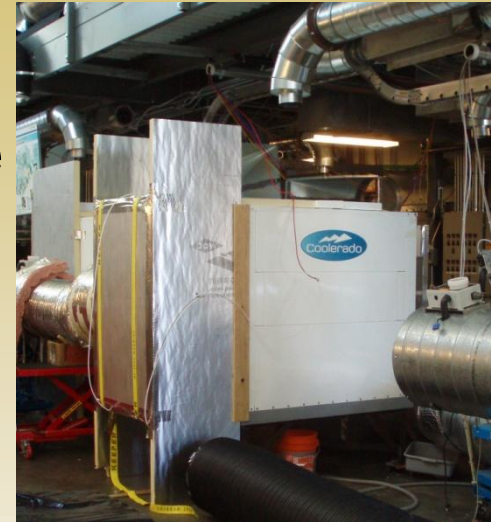
WCEC Initiative: Western Cooling Challenge

- **Target Market**
 - Roof-Top Units (RTUs) with 3 – 30 ton capacity
- **Target Performance**
 - 40% reduction in energy use and peak electricity demand
 - Achievable without complete redesign
- **Reward Structure**
 - MOUs w IOUs and SMUD for incentives
 - Retailer program sponsorship

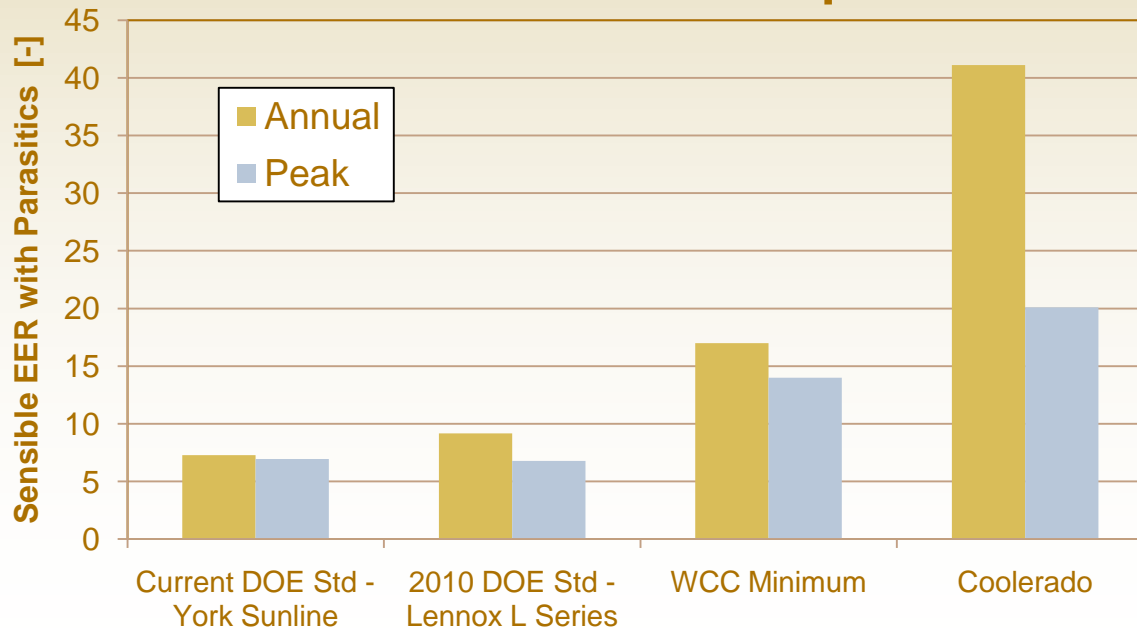


WCEC Initiative: Western Cooling Challenge

- **Current Status**
 - Coolerado RTU first to meet the Challenge
 - Testing completed at NREL
 - Inspired Press Release by UC Davis



WCC Performance Comparison

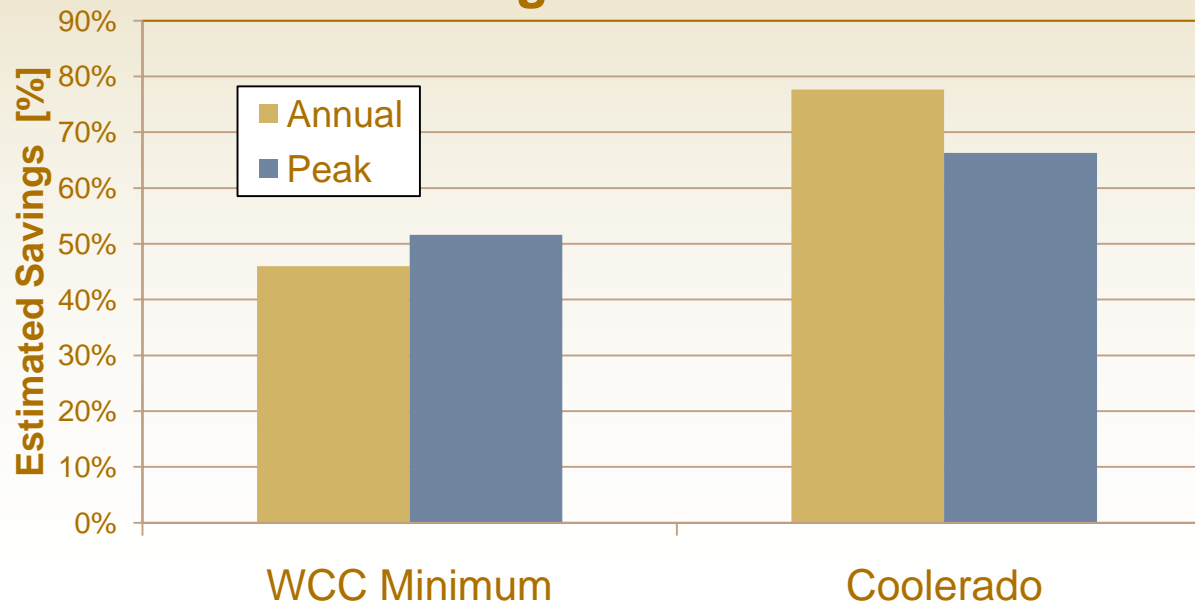


WCEC Initiative: Western Cooling Challenge

- **Current Status**

- Projected savings from single WCC test points - EnergyPlus simulations in process
- Second entry successfully bench tested in Phoenix
- Working with CA utilities to develop incentive programs

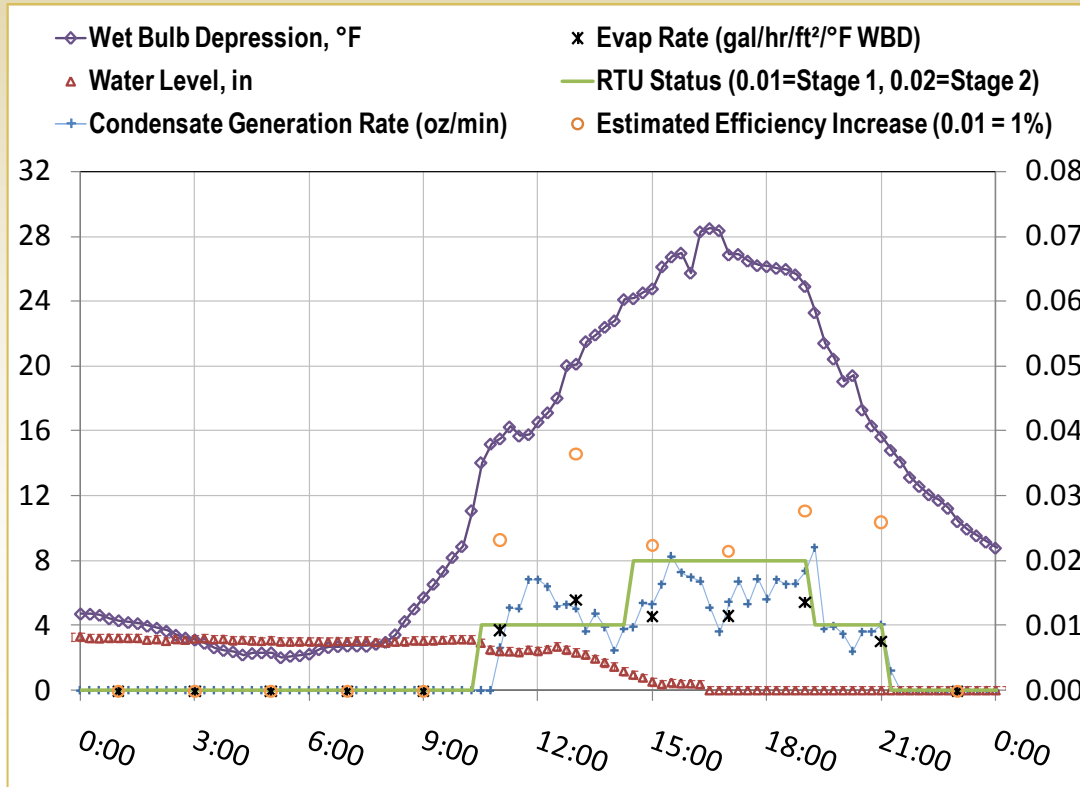
Savings vs. DOE 2010



RTU Retrofit: Wickool

Concept

- Evaporate condensate at condenser
- Eliminate need for condensate piping
- Provide modest efficiency improvement



Emerging Technology for Cooling in the West:

New-Construction Radiant Floor

- Prior cost \$6-7/ft²
- Rollout cost ~\$2/ft²
- Full-scale installations at Wal-Mart stores
- Allows better utilization of evaporative cooling
- Currently investigating non-chemical water treatments



Radiant Floor or Ceiling Benefits

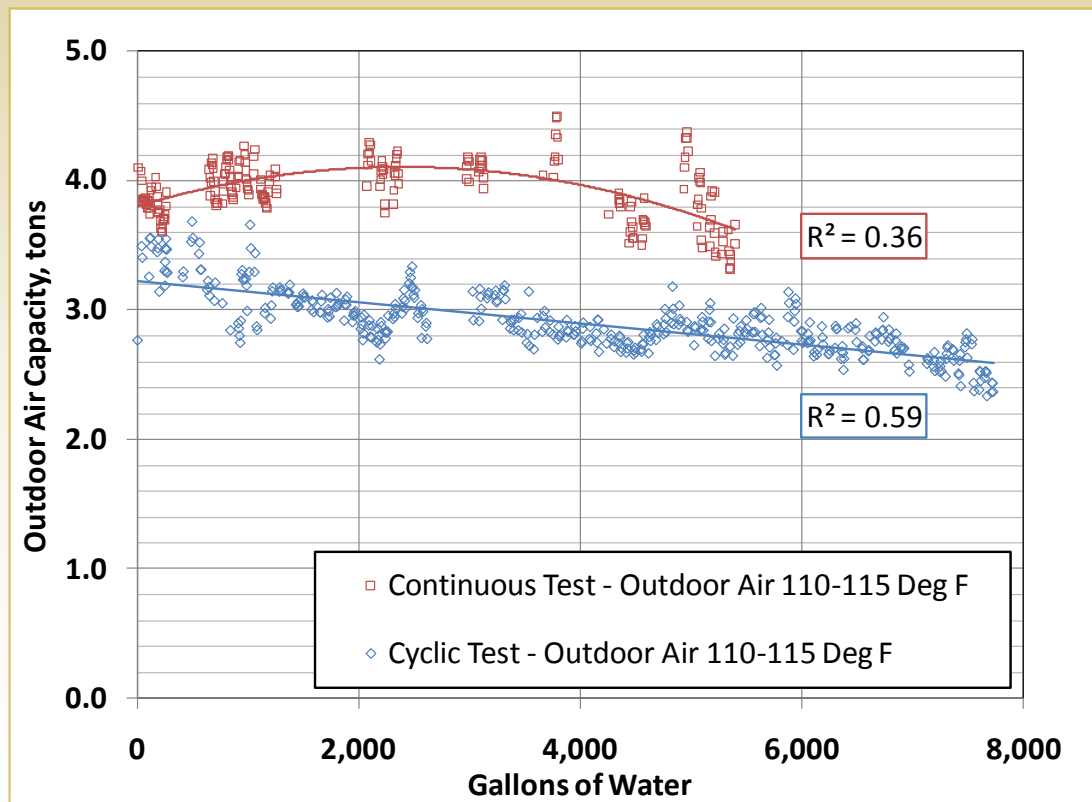
- Reduces latent cooling and blower energy
- Facilitates non-compressor cooling
- Projected savings 60-65%
- Attractiveness depends on ventilation rules



Western Cooling Issue: Water Consumption

Accelerated Testing: Impact of Hard Water

- OASys Indirect/Direct Evaporative System
- Initial testing with no maintenance water

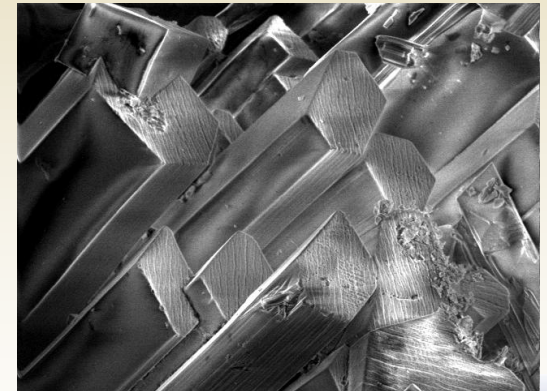
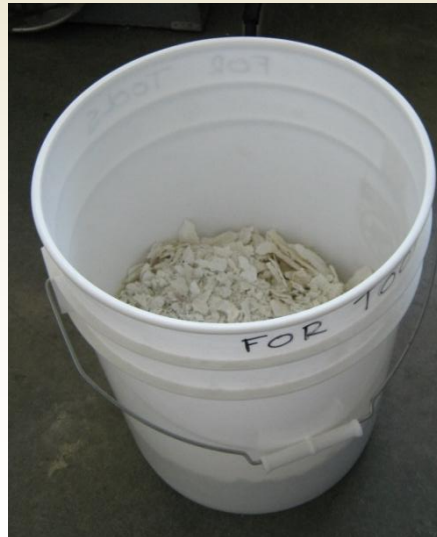


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Evaporative Testing: OASys

Results

- Performance degradation clearer in cyclic testing (approximately **17%** after **8000** gallons of water)
- Long test period required to impact performance - not practical for testing water treatment or purge cycle frequency
- Other evaporative technologies may be more sensitive to hard water.



Combined On-Site and Off-Site Water Use

Cooling System*	New Mexico [Gal/ton-hr]	Arizona, Nevada [Gal/ton-hr]
Conventional	1.2	9.6
Conventional w/ evap pre-cooling	2.3	8.8
Indirect Evaporative	3.2	6

On-Site Water Use

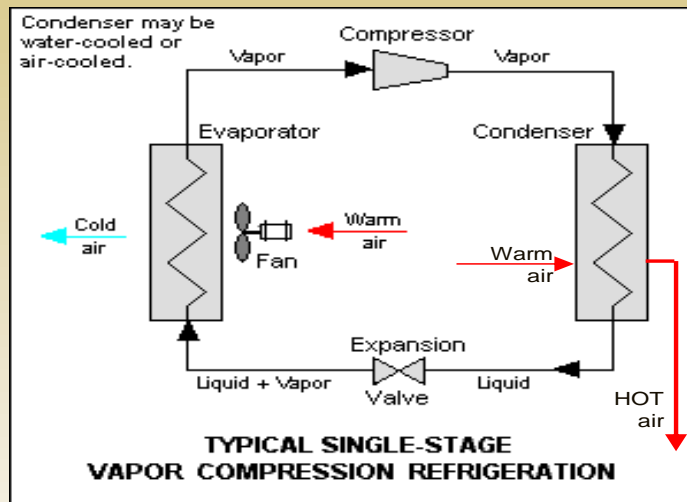
- Rainwater Capture and Storage
- Grey-water Treatment



* Using 30 EER for evaporative, 10 EER for compressor, 15 °F avg WB depression, and 1.5%/°F impact of condenser inlet air temperature on efficiency

Future Cooling Technologies

Heat Exchange vs. Refrigeration Circuit



$$\eta_{\max} = \frac{T_{\text{cold}}}{(T_{\text{hot}} - T_{\text{cold}})}$$

T_{cold}	T_{hot}	COP	EER
80°F	95°F	36	123
45°F	140°F	5	18

Emerging Western Cooling: Summary

Existing RTUs

- Western Cooling Challenge
- Wickool

Radiant Cooling in New Construction

- Residential and Commercial

Need to Address Water Consumption

- Rainwater capture - grey-water treatment

Future Trends

- Heat Exchange vs. Refrigeration Circuit

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