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Water and the Electric Power Sector

Robert (Bog) Goldstein (rogoldst@epri.com)
Senior Technical Executive, Water and Ecosystems

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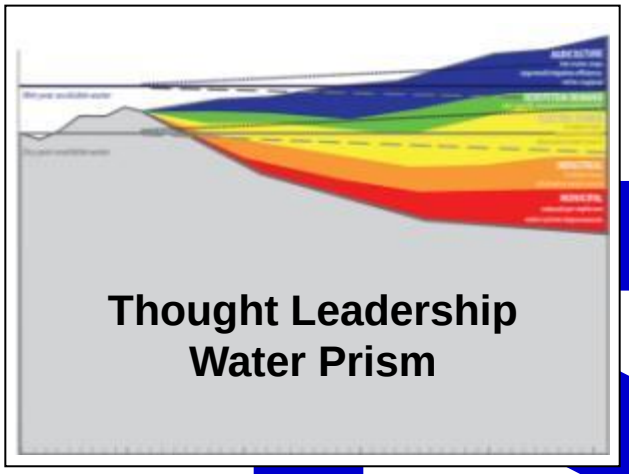
Co-Authors

- Richard Breckenridge (rbreckenridge@epri.com)
- Sean Bushart (sbushart@epri.com)
- George Offen (goffen@epri.com)
- Jessica Shi (jshi@epri.com)
- Kent Zammit (kezammit@epri.com)

EPRI R&D Strategy
Water Resource Management



A Cross Sector EPRI R&D Team Executing the Water R&D Strategy

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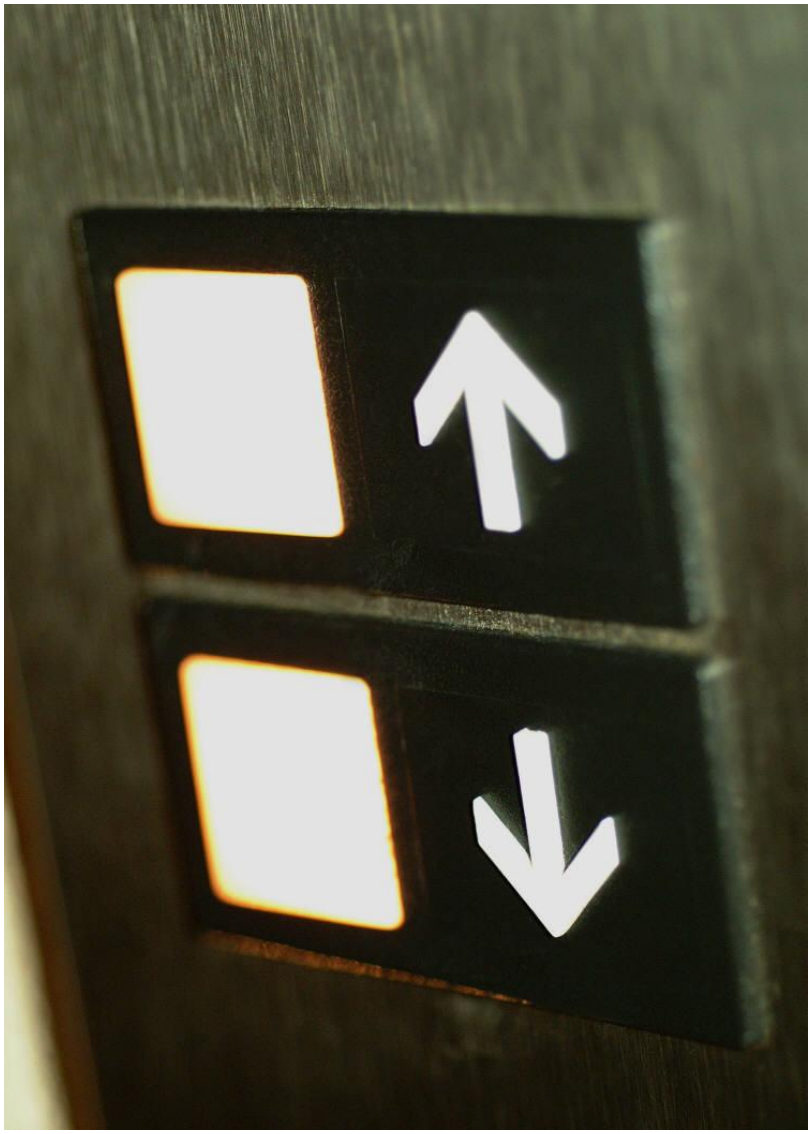
Approaches to Reaching Sustainability

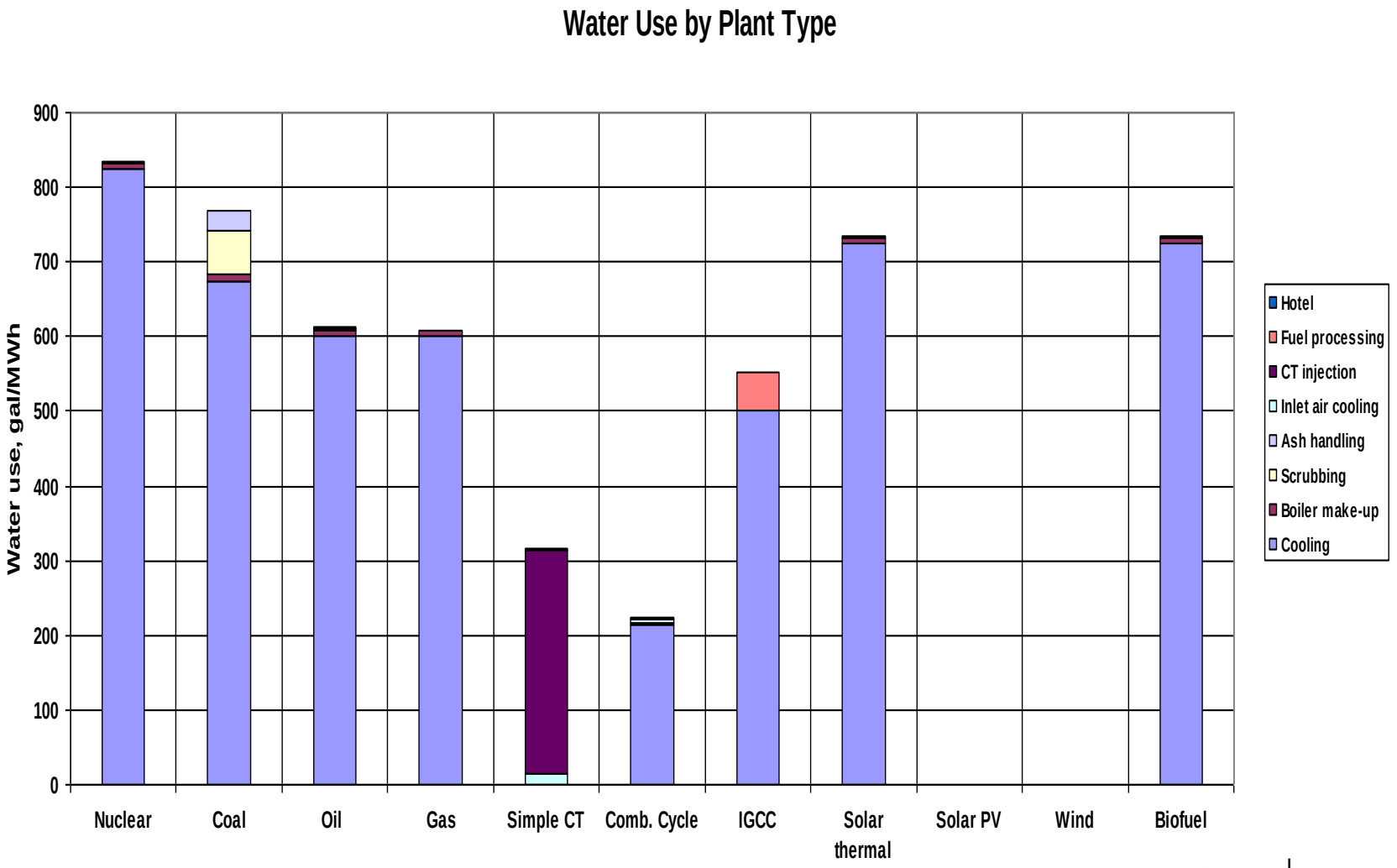


- Top down
  - Community/region/watershed-based
  - Considers all stakeholder demands
  - Matches aggregate water demands to supply
- Bottom up
  - Sector/Facility-based
  - Objectives
    - Increase water use efficiency
    - Conservation

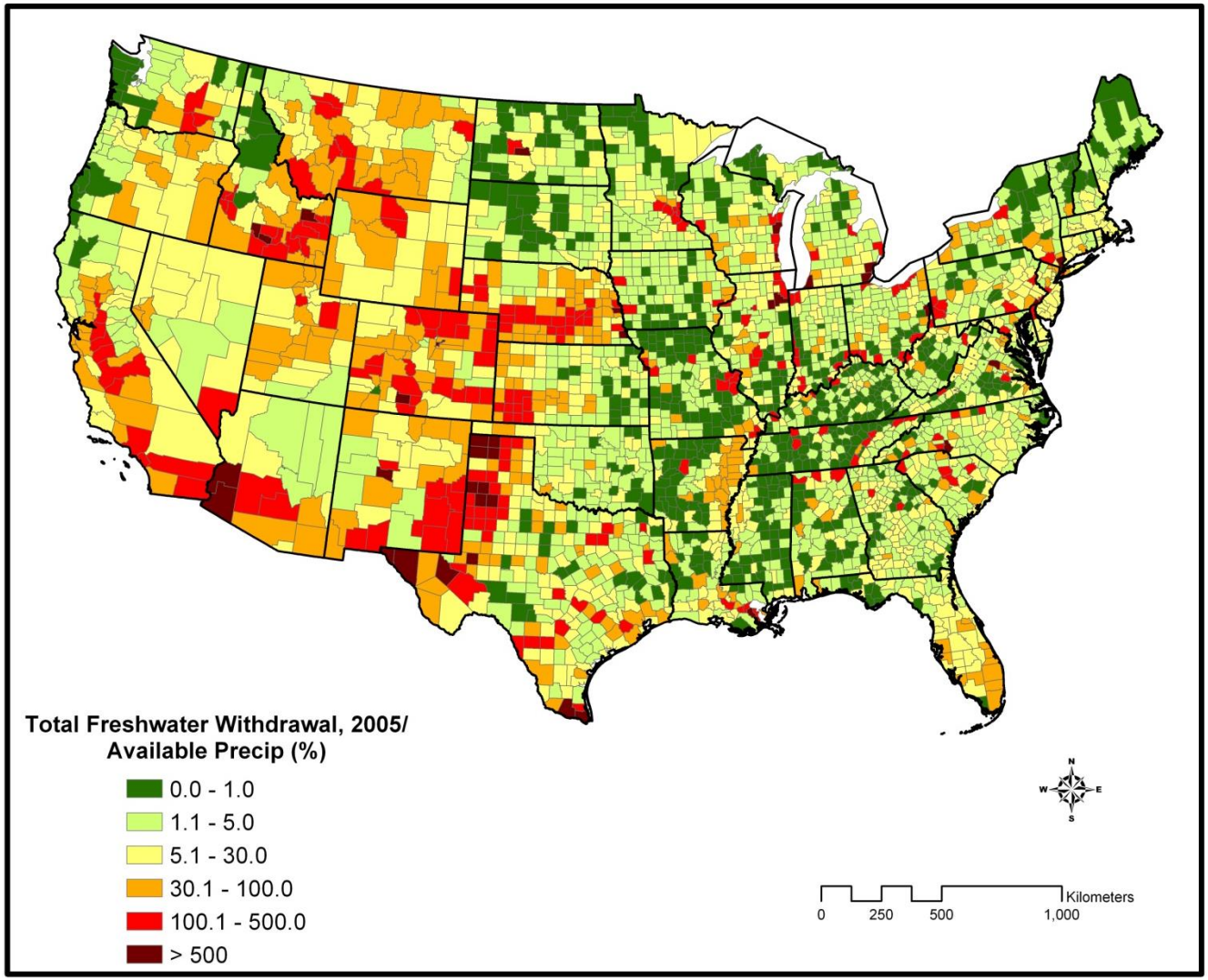
Thermoelectric Power Plant Strategies to Reduce Freshwater Demand

- Advanced cooling technologies
- Recycled water within plant
- Degraded/reclaimed/ non-traditional water sources
- Increased thermal energy conversion efficiency

Water Use Efficiency
(Thermoelectric Plants Using Wet Cooling Tower)



Sustainability: Total Freshwater Withdrawal (2005)/Average Available Precipitation (1934-2005)



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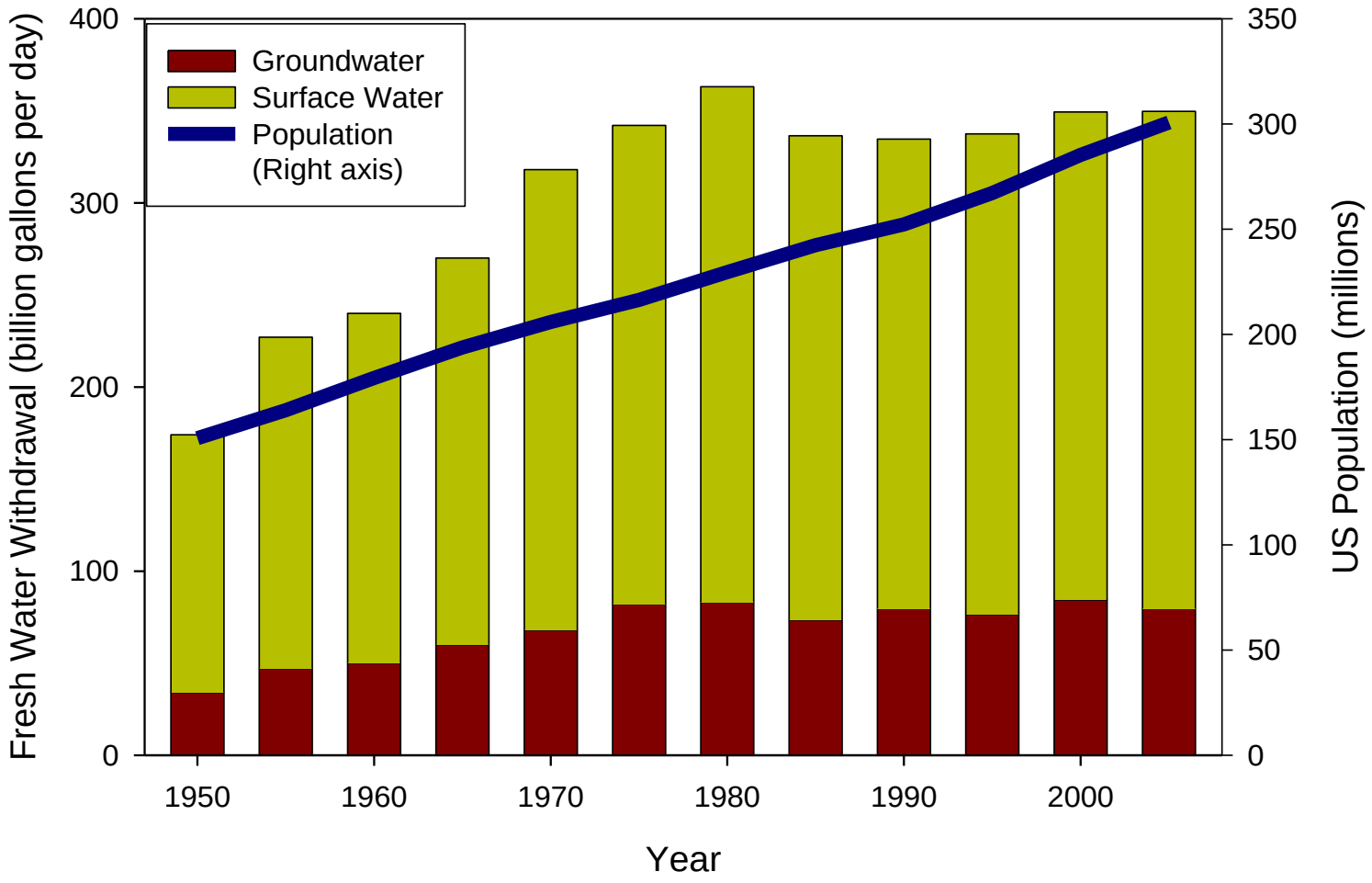
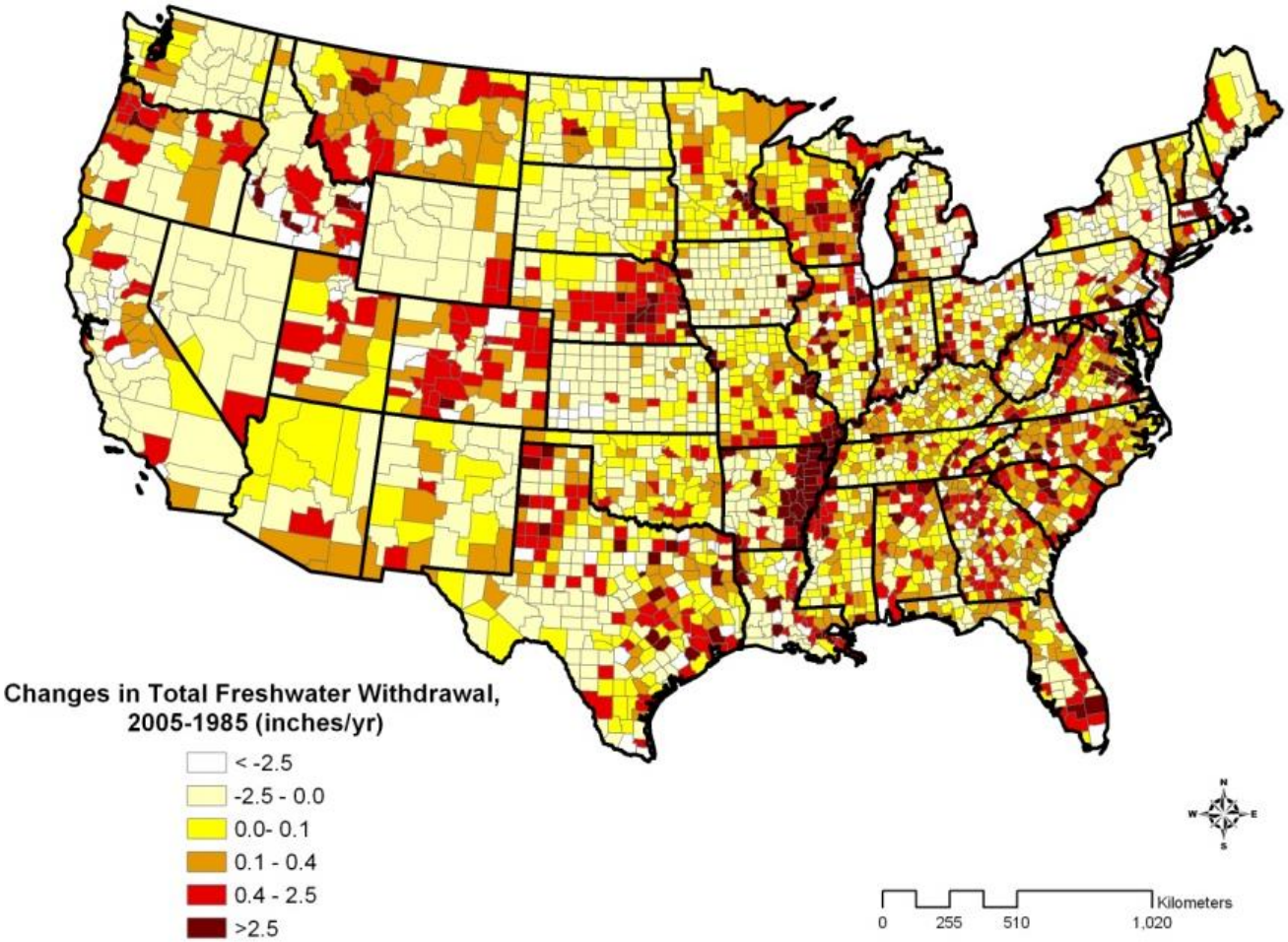
National Freshwater Withdrawals by Year



Change in Freshwater Withdrawal 2005-1985



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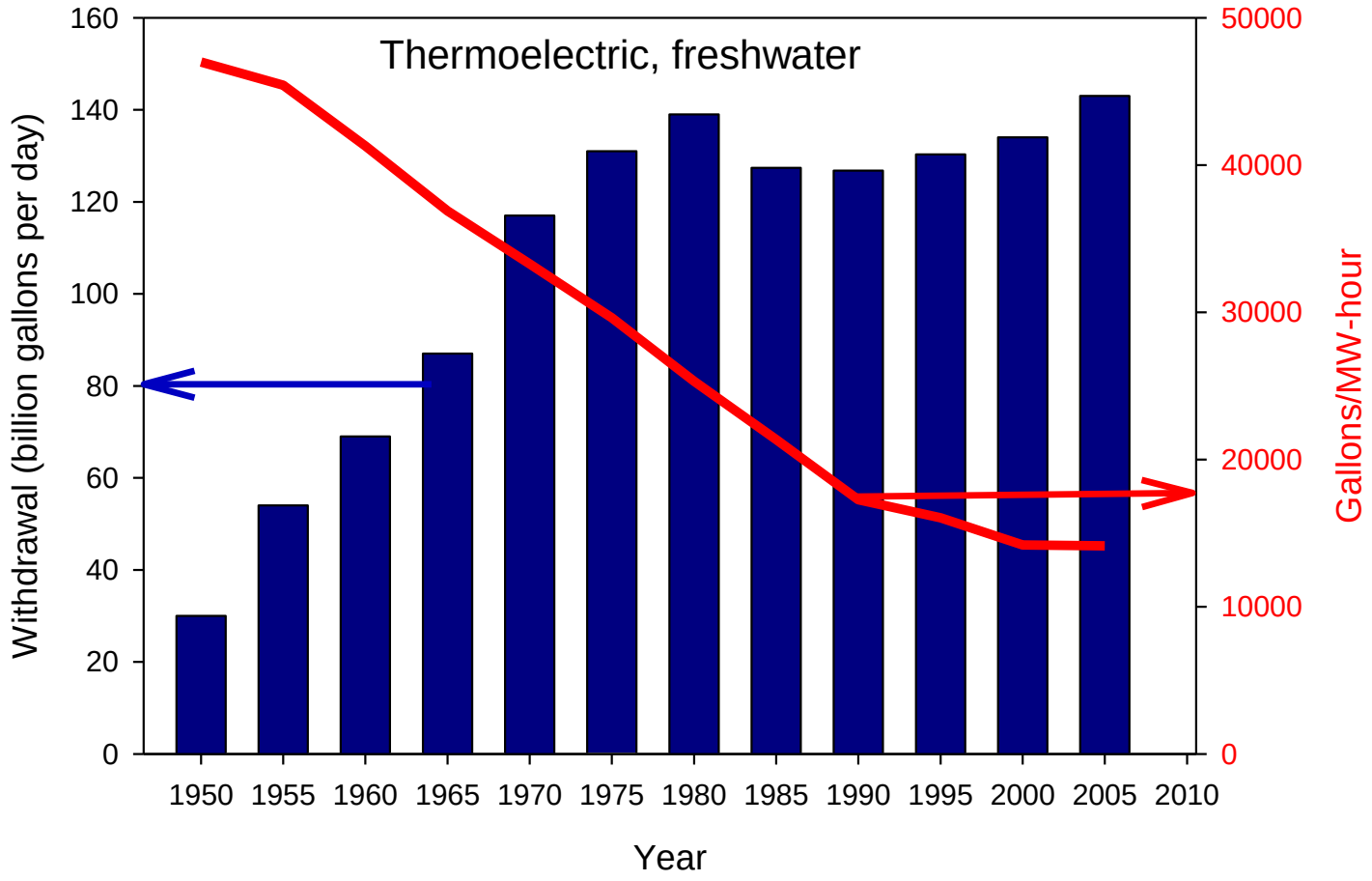
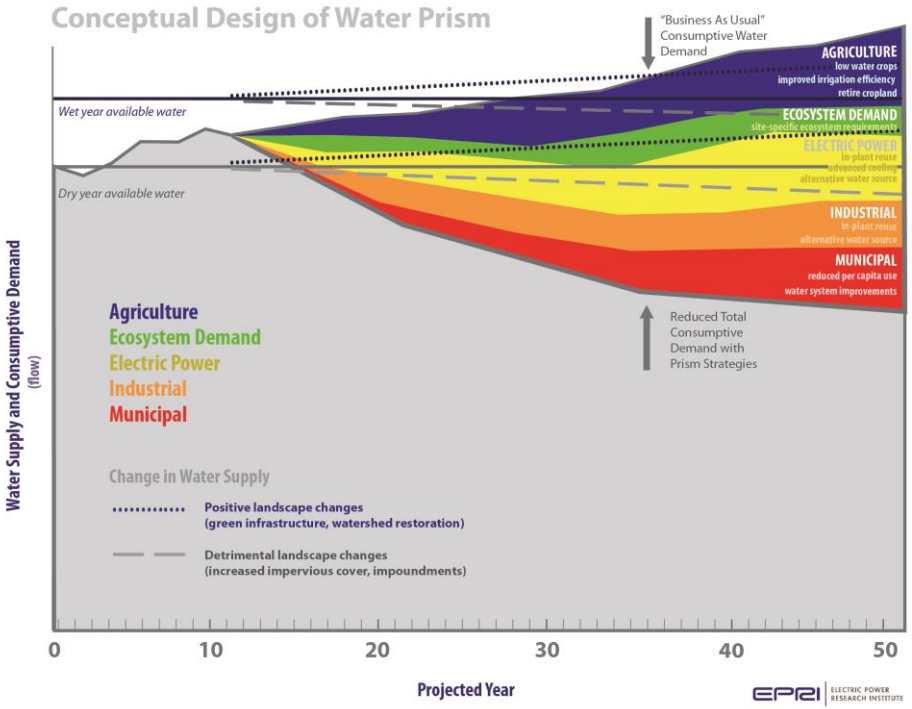
Trend in Thermoelectric Water Withdrawals



Water Prism: Conceptual Design

- Compute system water balance on regional scale
  - Available surface water informed by a watershed model
  - Include groundwater sources and uses
- Project consumptive demand for 40 to 50 year horizon
- Explore water saving strategies through scenario analysis
- Give it the "feel" of EPRI's CO_2 Prism – graphical displays



Examine various scenarios to consider water use reductions needed to keep "demand" below "supply"

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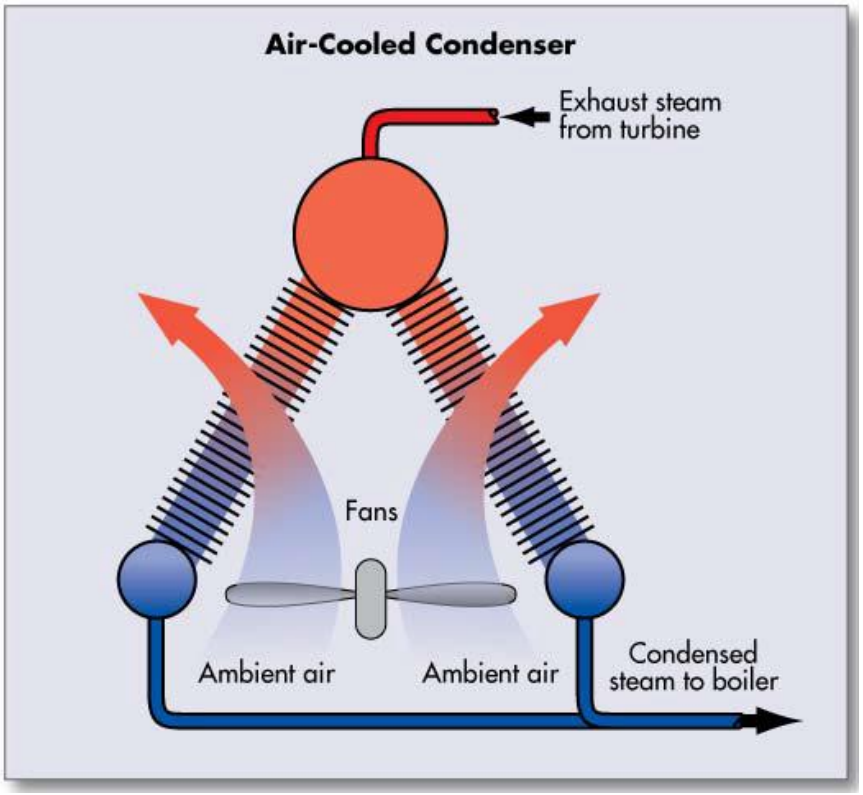
Water Use for Electric Power Generation

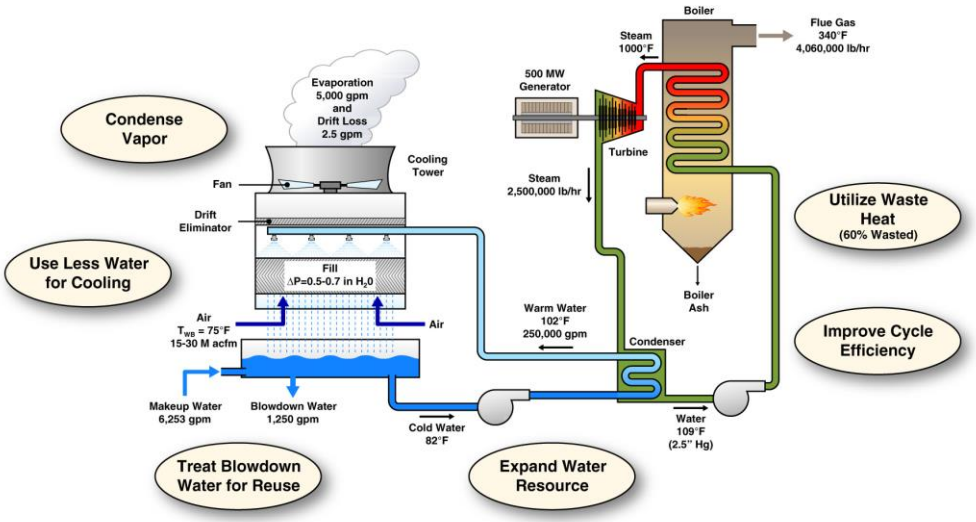
- EPRI Report 1014026 (www.epri.com)
- Overview of water requirements
- Conventional wet cooling
- Water recovery, recycling and reuse
- Dry cooling technology
- Alternatives to freshwater supply
- Economics of water
- Case studies of different plants operating in various regions of the U.S.



Power Plant Cooling System Overview for Researchers and Technology Developers

- http://mydocs.epri.com/docs/CorporateDocuments/TechnologyInnovations/Pwer-Plant-Cooling-System.pdf
- Cooling system types
- Cost, performance, and design data for various types of cooling systems
- Approaches to water use reduction

Opportunities for Power Plant Water Use Reduction



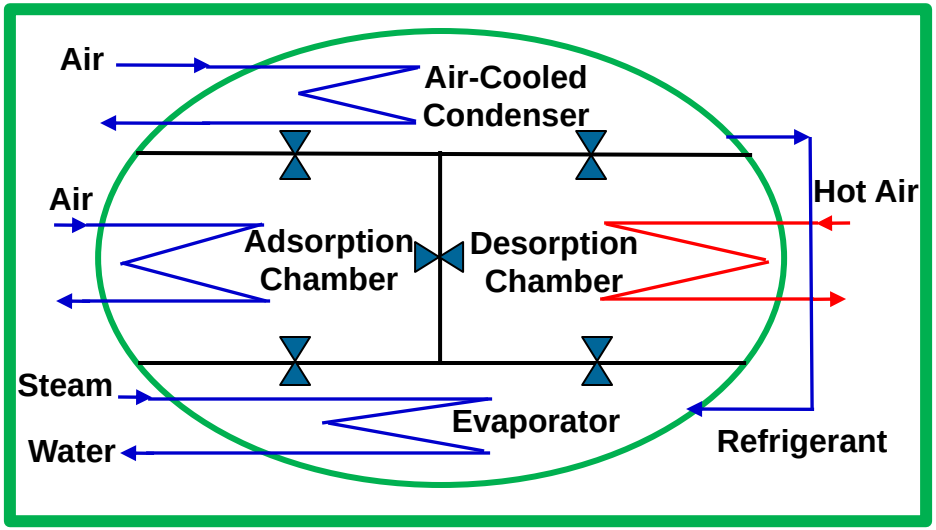
EPRI Water Innovation Program: Progress Summary

Progress Since 2011 Program Initialization

- Received 114 proposals from Request for Information Solicitations.
- Funded 11 projects, including three *exploratory* type projects
- Published ten reports and briefs (http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001025771&Mode=download&Mode=download)
- Filed one patent application
- Co-hosted joint workshop and released **2013 joint solicitation with the National Science Foundation.**

Waste Heat Driven Green Adsorption Chillers for Steam Condensation (Collaboration with Allcomp)

Schematic Illustration of a Typical Adsorption Chiller



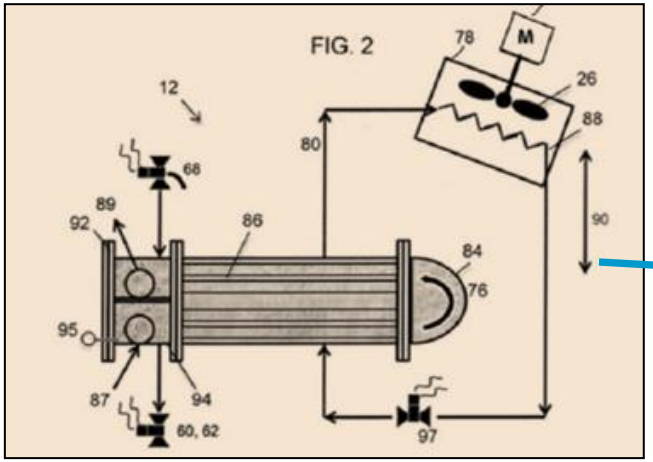
Key Potential Benefits

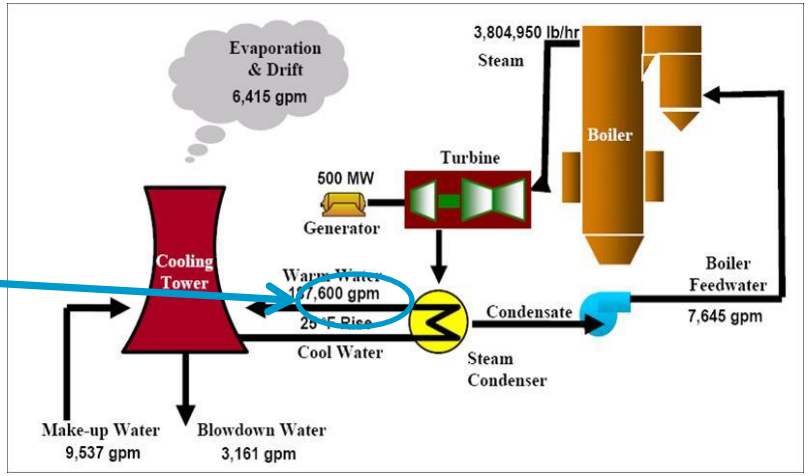
- Dry cooling system
  - **Near Zero** water use and consumption
- Reduced condensation temperature
  - As low as **35 ℃**
  - Potential for annual power production increase by up to 5%
- Full power production even on the hottest days compared to air cooled condensers.

Phase 1 Project Update (EPRI Patent Pending)

- Developed several power plant system level approaches to utilize waste heat or solar heat for desorption
- Performed system integration energy and mass flow balance analysis for a 500 MW coal-fired power plant
- Performed technical and economic feasibility study
- Finalizing final report.

Thermosyphon Cooler Technology (Collaboration with Johnson Controls)





Project Update

- Performed a thorough feasibility evaluation of a hybrid, wet/dry heat rejection system comprising recently developed, patent pending, thermosyphon coolers (TSC).
- Made comparisons in multiple climatic locations, to standard cooling tower systems, all dry systems using ACC's, hybrid systems using parallel ACC's, and air coolers replacing the thermosyphon coolers.
- Determined the most effective means to configure and apply the thermosyphon coolers.
- Completed final project review on March 5th.

Key Potential Benefits

- Potential annual water savings up to 75%
- Compared to ACC, full plant output is available on the hottest days
- Ease of retrofitting
- No increase in surface area exposed to primary steam
- Reduced operating concerns in sub freezing weather
- Broad application for both new and existing cooling systems for fossil and nuclear plants)

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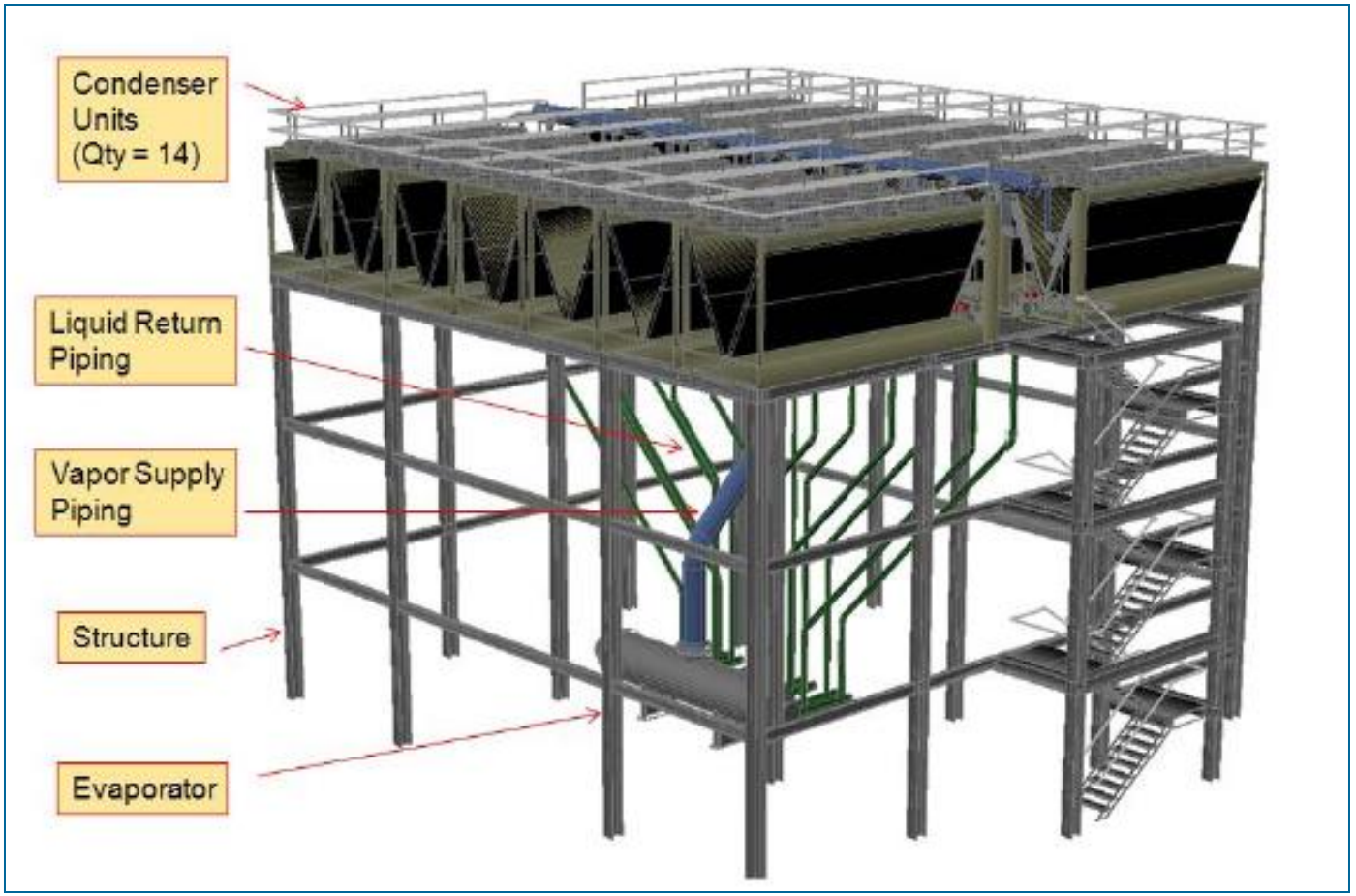
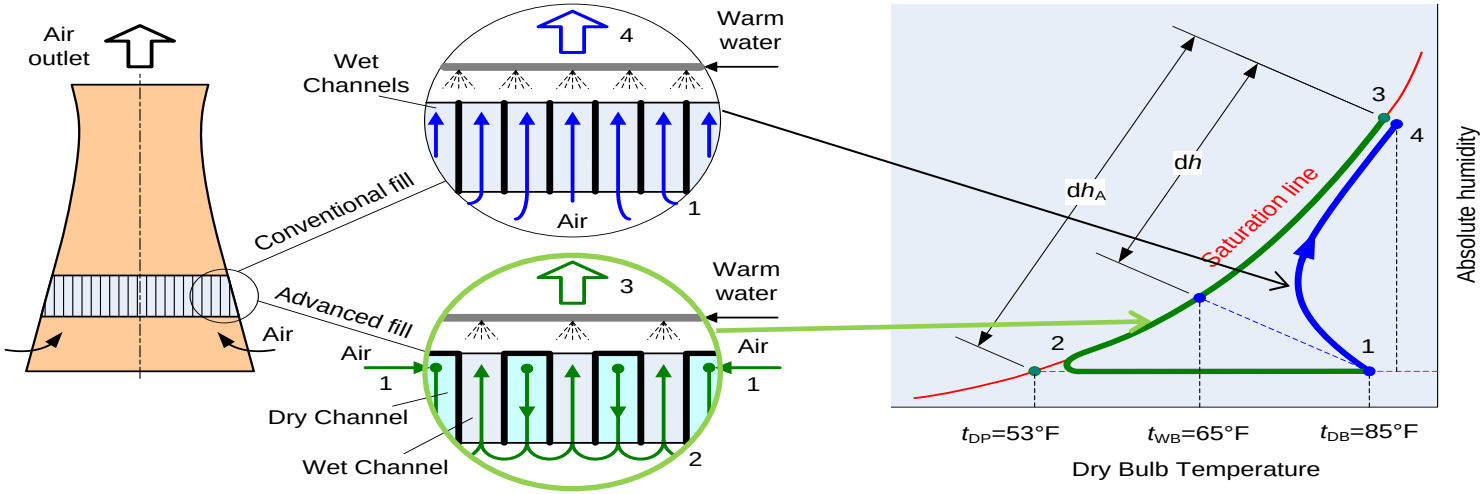
Thermosyphon



Advanced M-Cycle Dew Point Cooling Tower Fill (Collaboration with Gas Technology Institute)



Project Scope

- Develop an advanced fill
- Perform CFD and other types of energy, mass, and momentum balance modeling
- Evaluate performance and annual water savings for several typical climates using simulation models
- Perform testing in lab
- Perform technical and economic feasibility evaluation

Key Potential Benefits

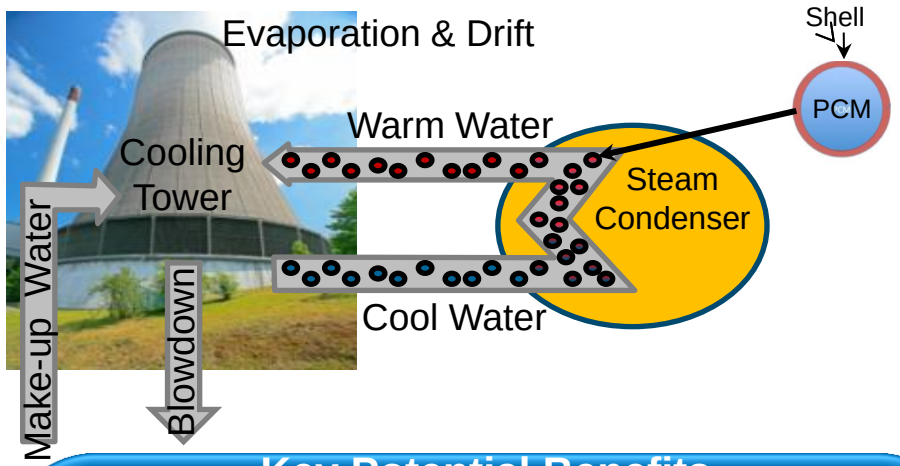
- Potential for less cooling water consumption by up to 20%
- Lower cooling tower exit water temperature resulting in increased power production
- Ease of retrofitting
- Broad applications

Heat Absorption Nanoparticles in Coolant (Collaboration with Argonne National Laboratory)

Project Scope

- Develop multi-functional nanoparticles with ceramic shells and phase change material cores
- Measure nano-fluid thermo-physical properties
- Perform testing in lab
- Assess potential environmental impacts due to nanoparticle loss to ambient air and water source.
- Perform technical and economic feasibility evaluation

Phase Change Material (PCM) Core/Ceramic Shell Nano-particles added into the coolant.



Key Potential Benefits

- Up to 20% less evaporative loss potential
- Less drift loss
- Enhanced thermo-physical properties of coolant (e.g., latent heat, specific heat capacity)
- Inexpensive materials
- Ease of retrofitting
- Broad applications (hybrid/new/existing cooling systems)

Water Research Center
(Plant Bowen, Euharlee, GA)

Concluding Thoughts

- There is no such thing as Business as Usual - everything is evolving with time
- Everything is geographically distributed non-uniformly
- Top down management is necessary for sustainability
- Need localized, fine resolution decision support tool to manage community (watershed, region) water resources
- Strategic and technological approaches depend on location
- Research can lead to promising breakthrough technologies to save water