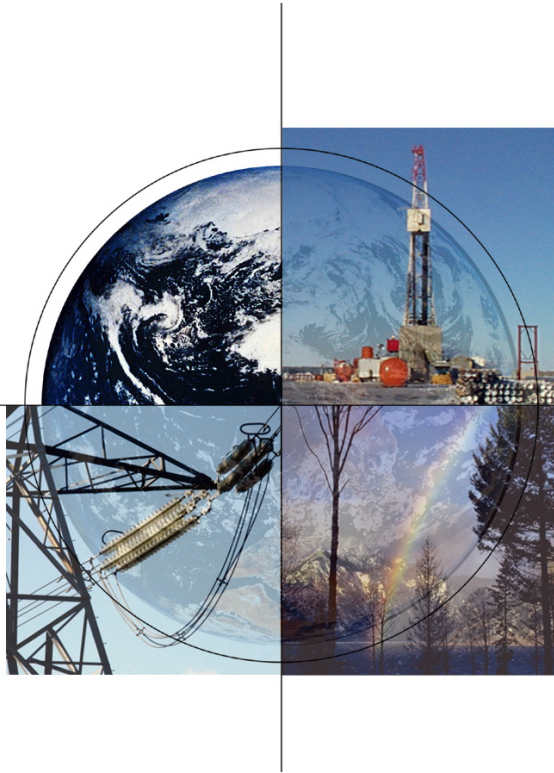


Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements in Western United States



*First Western Forum
on Energy & Water
Sustainability*

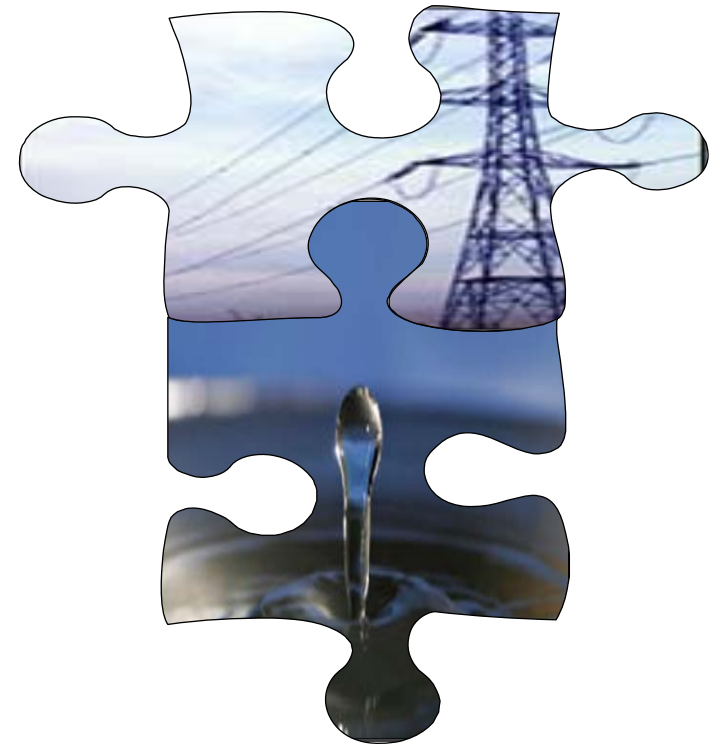
*March 22-23, 2007
University of California
Santa Barbara, CA*

Thomas J. Feeley, III
National Energy Technology Laboratory



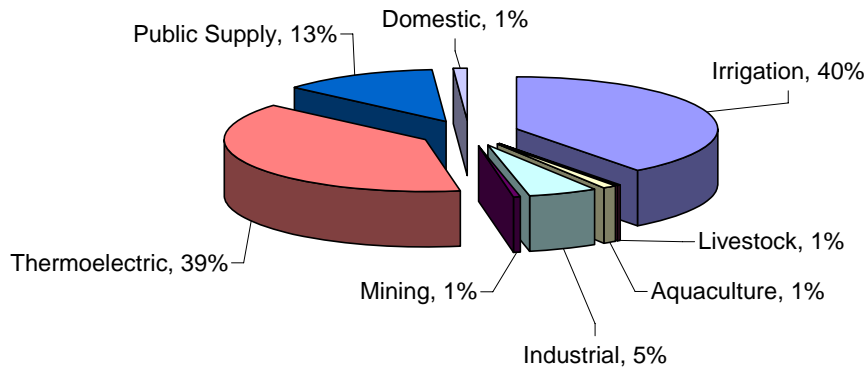
Outline

- Background on issue
- Thermoelectric withdrawal and consumption projections
- NETL's R&D program
- Estimated benefits of R&D
- Summary



The Issues: Competing Water Uses

U.S. Freshwater Withdrawal (2000)

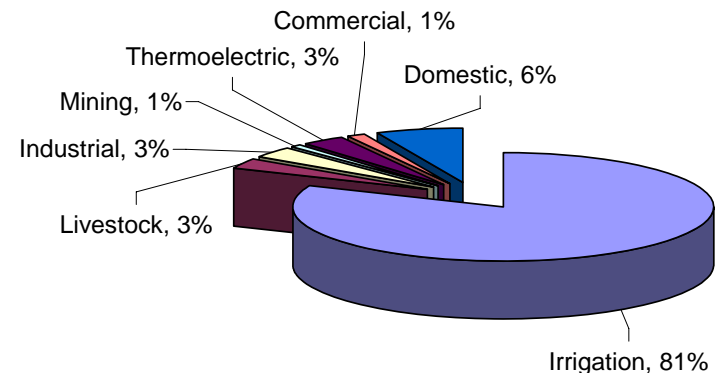


- **2000 thermoelectric water requirements:**

- **Withdrawal: ~ 136 BGD**
- **Consumption: ~ 3 BGD**

- **Thermoelectric competes with other users, including in-stream use.**
- **Which is more important: drinking and personal use, growing food, or energy production?**

U.S. Freshwater Consumption (1995)



Sources: USGS, Estimated Use of Water in the United States in 2000, USGS Circular 1268, March 2004
USGS, Estimated Use of Water in the United States in 1995, USGS Circular 1200, 1998

Recent Articles on Water-Related Impacts on Power Plant Siting and Operation

Idaho May Adopt Moratorium on Coal Power Due to Water Issues
- *Reuters*, March 2006

California's Efforts to End Use of Sea Water to Cool Plants Could Jeopardize 24 GW
- *POWERnews*, October 2006

Energy Project Could Threaten Water Supply in Salina, Kansas
- *McClatchy-Tribune Business News*, November 2006

Desert Rock Water Agreement Passes Navajo National Committee
- *The Daily Times*, February 2006

Southern Drought Leads to Shutdown of Hydro, Forcing Utilities to Buy from Market
- *POWERnews*, October 2006



May 2006 Issue of Power Magazine

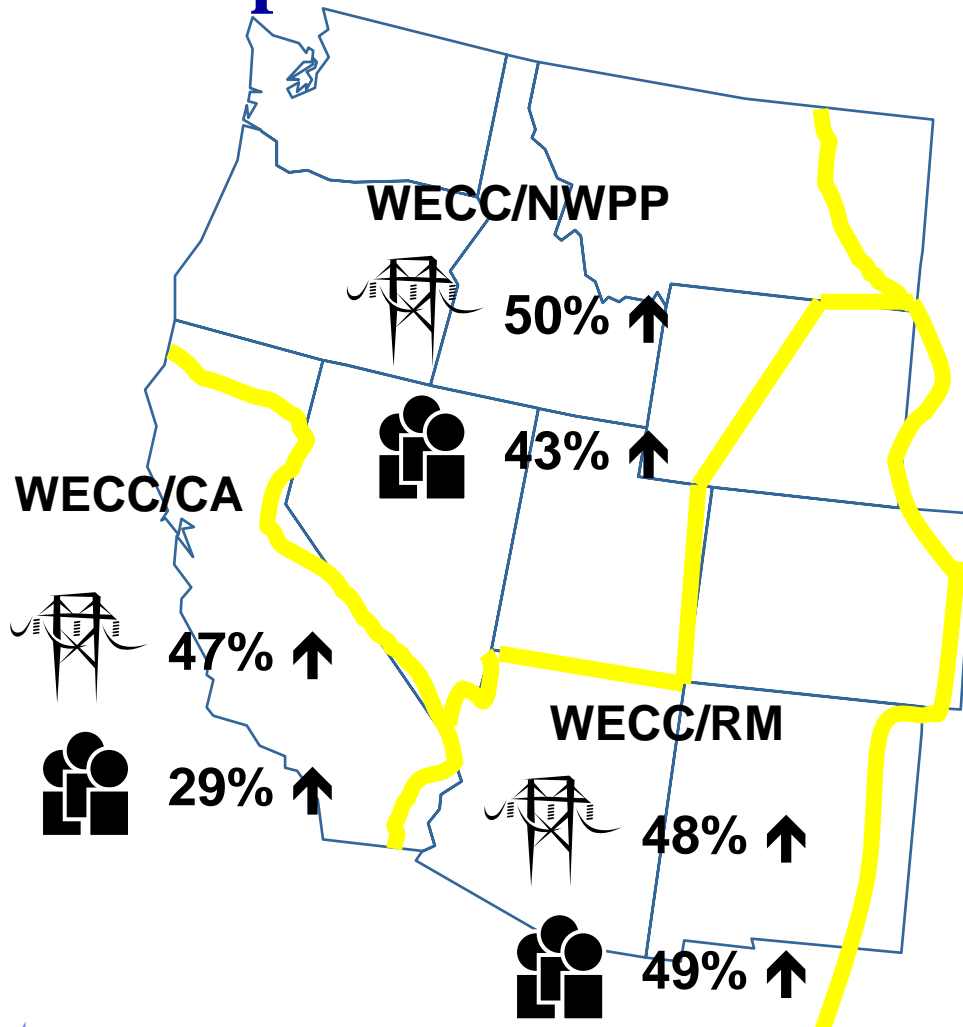


Summary of Generation Capacity Impacted by Water-Related Issues

Plant Generation Type	Generation Affected by Availability Issues (MW)	Generation Affected by Environmental Issues (MW)	Total Affected Generation (MW)
Pulverized Coal	17151	1200	18351
Hydro	8040	0	8040
Nuclear	4113	985	5098
Natural Gas/NGCC	1225	2887	4112
Total	30529	5072	35601

- New plants face difficulties in obtaining water withdrawal permits
- Existing plants face reduced generation

Projected Thermoelectric Capacity & Population Increases from 2005 to 2030



Regional Population and Thermoelectric Capacity Projected to Rise Significantly in the Future

Demands on our Limited Water Resources Expected to Constrain Regional Development

Sustainable Energy-Water Resource Strategies are Needed!

Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005. Energy Information Agency, Annual Energy Outlook 2006, Regional Tables, 2007.

North American Electric Reliability Council (NERC)

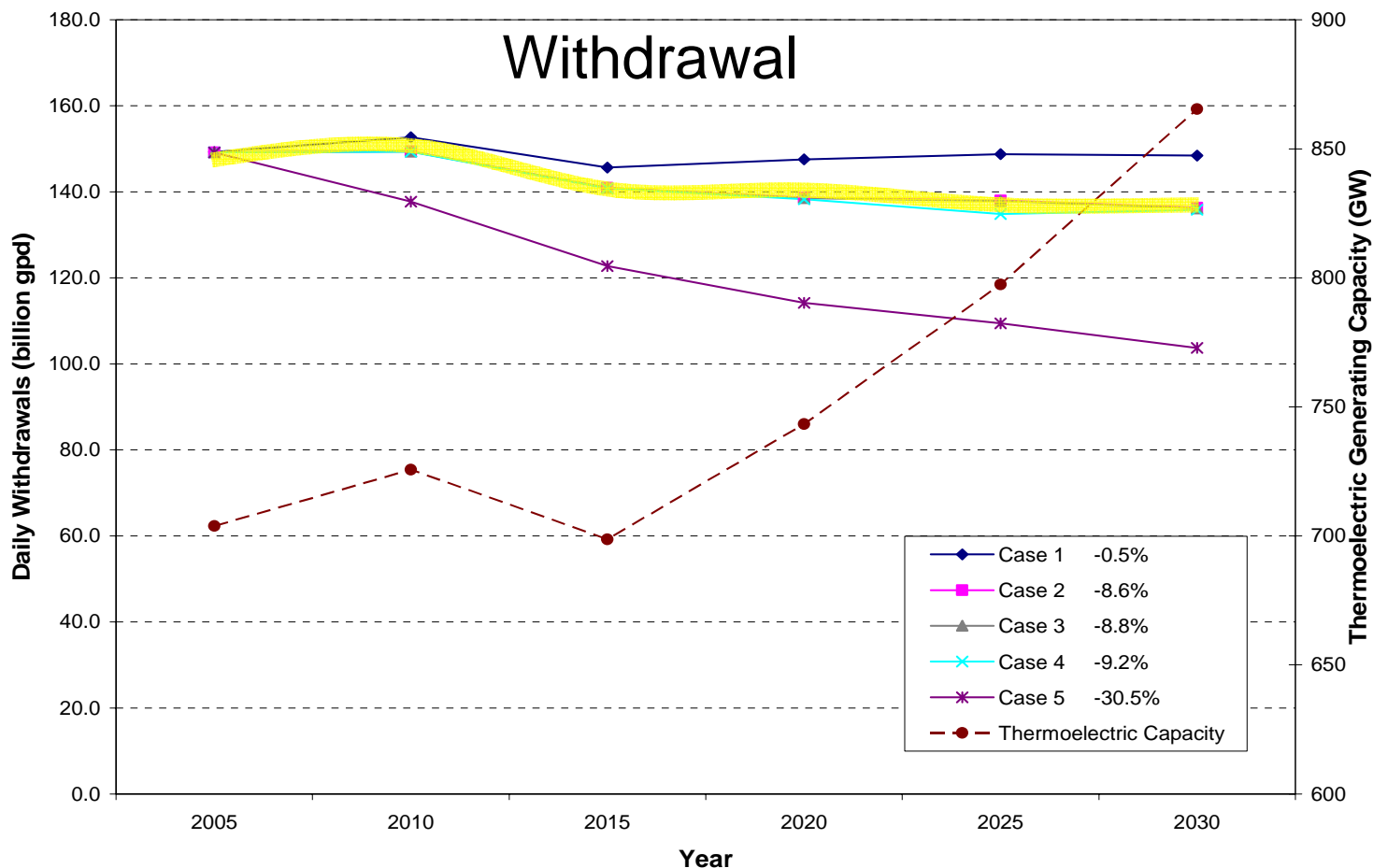


Water Use Projection Cases

- **Case 1 (Status Quo)** – Additions and retirements are proportional to current water source and type of cooling.
- **Case 2 (Regulatory Driven)** – All additions use freshwater and wet recirculating cooling (WRC), while retirements are proportional to current water source and type of cooling.
- **Case 3 (Regulatory Light)** – 90% of additions use freshwater and WRC, and 10% of additions use saline water and once-through cooling, while retirements are proportional to current water source and type of cooling.
- **Case 4 (Dry Cooling)** – 25% of additions use dry cooling and 75% of additions use freshwater and WRC, while retirements are proportional to current water source and type of cooling.
- **Case 5 (Conversion)** – Additions use freshwater and WRC, while retirements are proportional to current water source and type of cooling. 5% of existing freshwater once-through cooling capacity is retrofitted with WRC every five years starting in 2010.



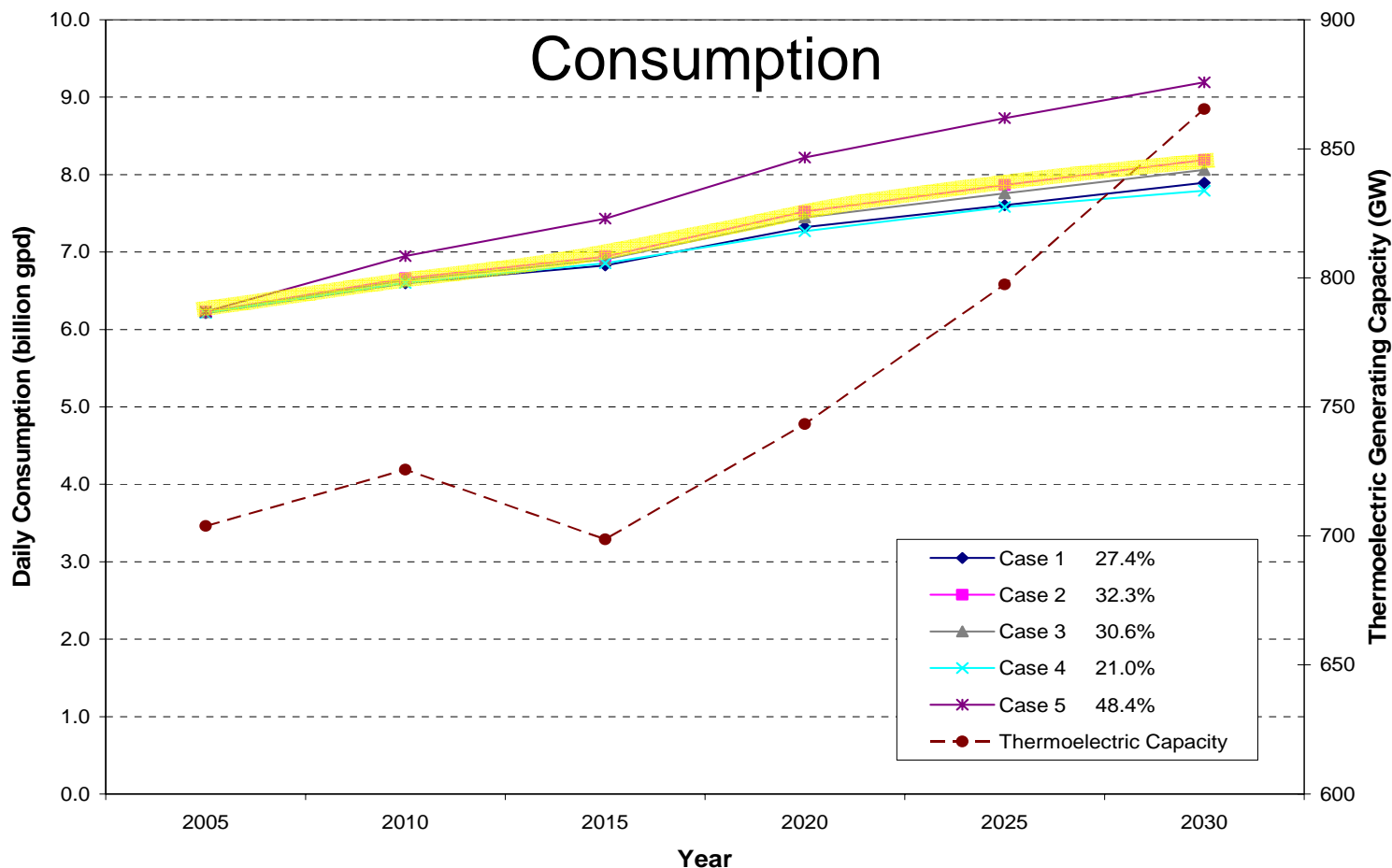
Projected Changes in U.S. Thermoelectric Sector Freshwater Withdrawal and Consumption



DOE/NETL, "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements," August, 2006 <http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WaterNeedsAnalysisPhaseI1006.pdf>



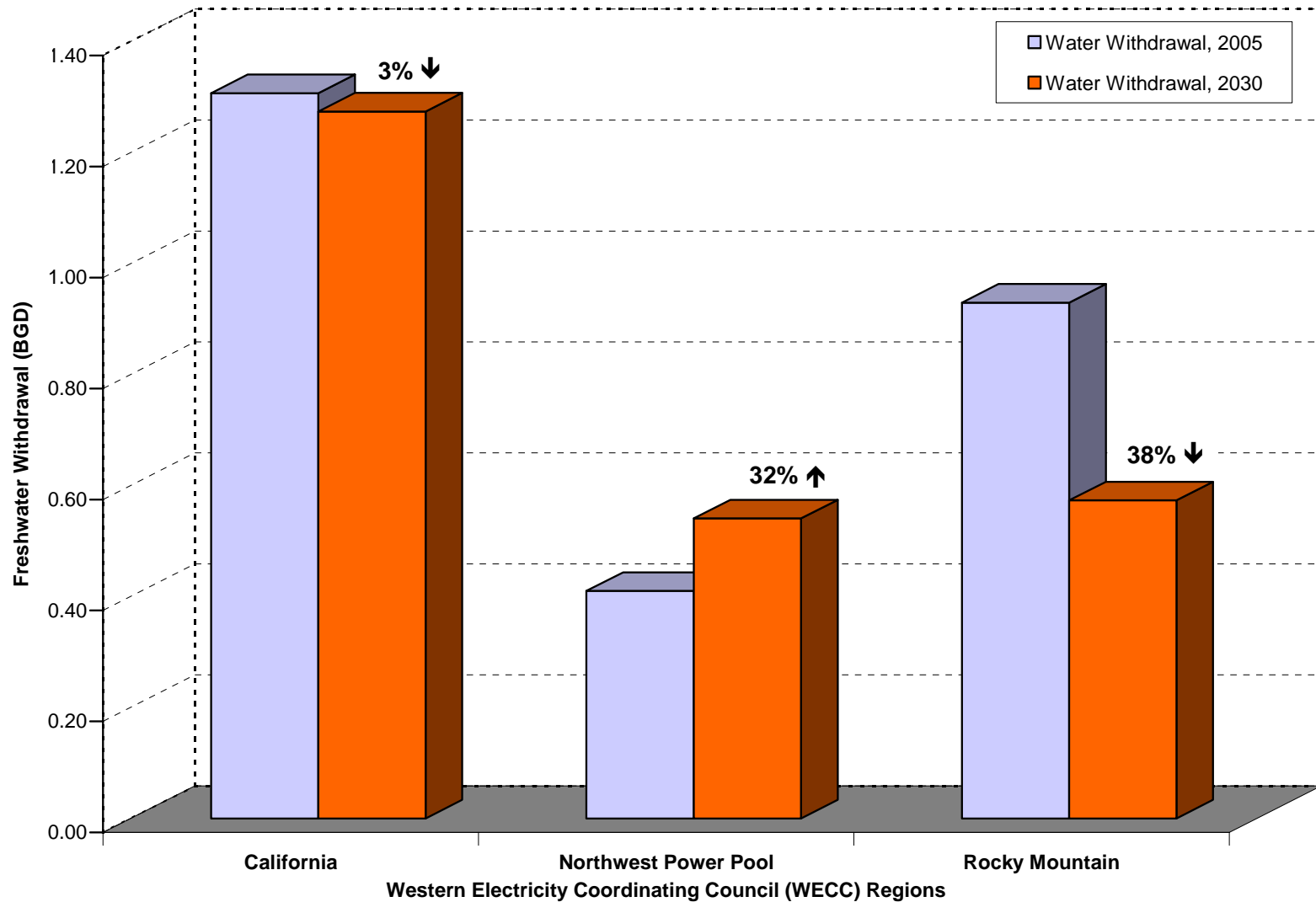
Projected Changes in U.S. Thermoelectric Sector Freshwater Withdrawal and Consumption



DOE/NETL, "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements,"
August, 2006 <http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WaterNeedsAnalysisPhaseI1006.pdf>



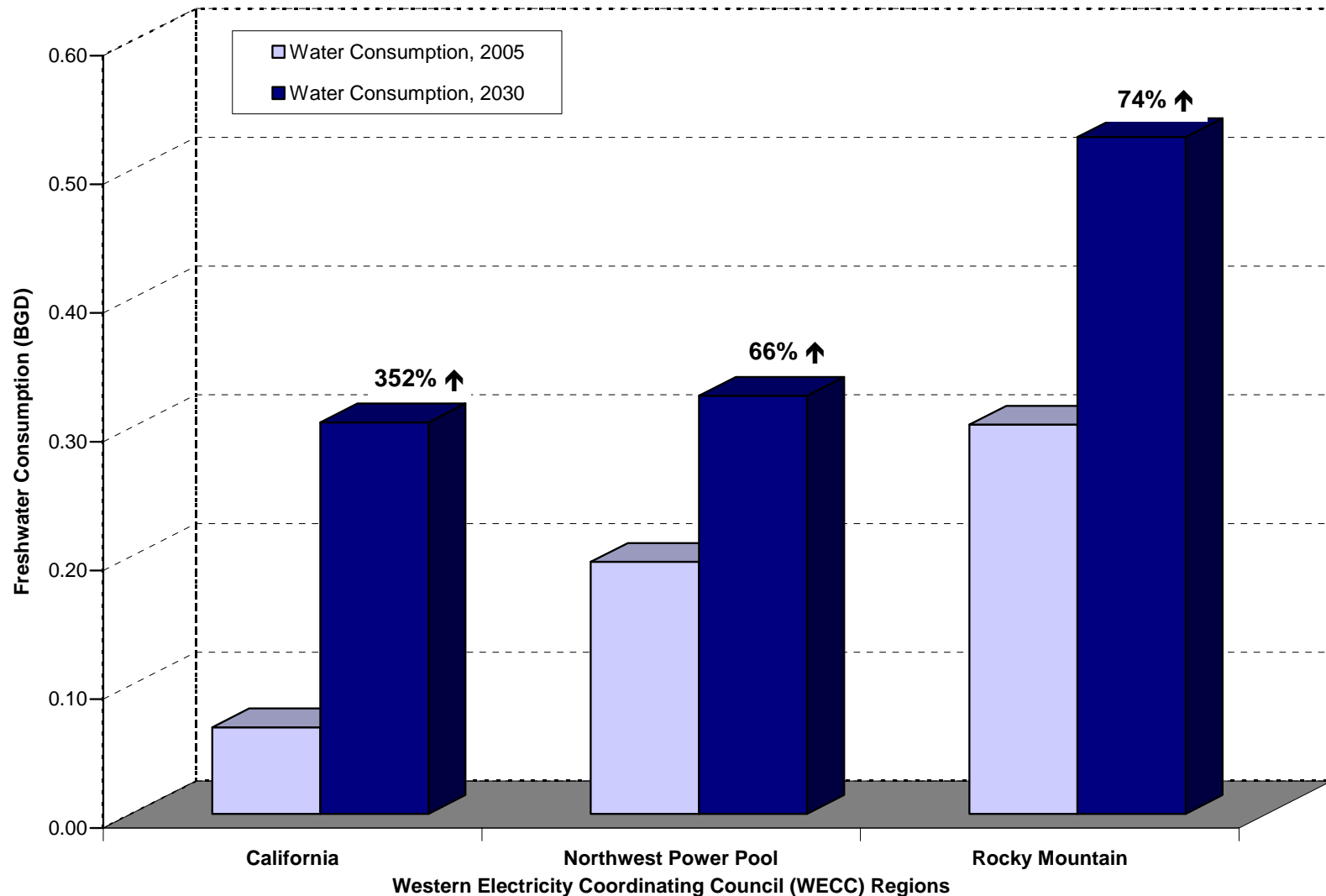
Regional Thermoelectric Withdrawal Results (Case 2)



DOE/NETL, "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements," August, 2006 <http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WaterNeedsAnalysisPhase1006.pdf>



Regional Thermoelectric Consumption Results (Case 2)

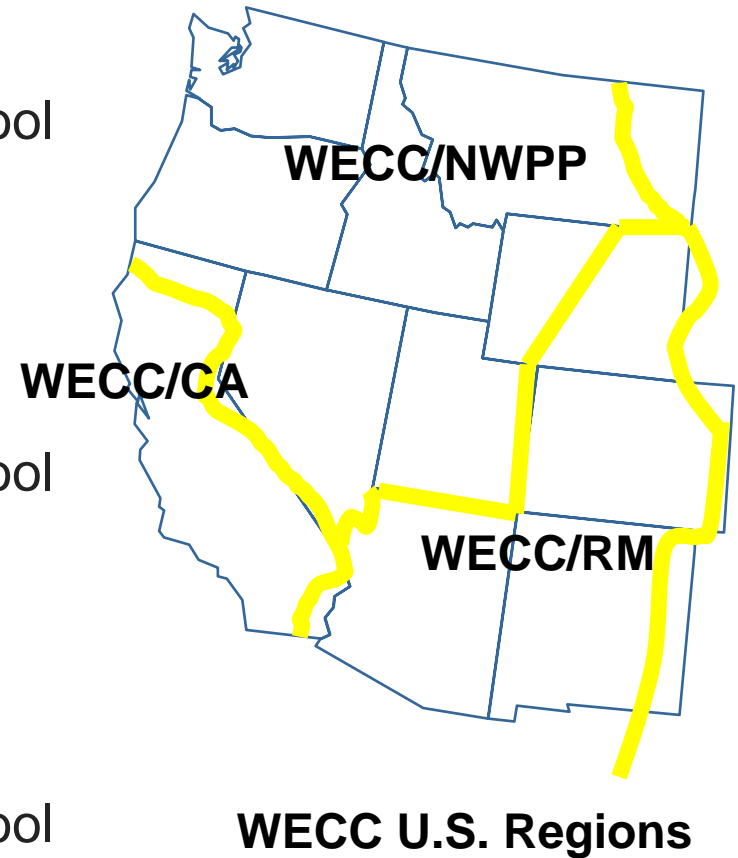


DOE/NETL, "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements," August, 2006 <http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WaterNeedsAnalysisPhase1006.pdf>

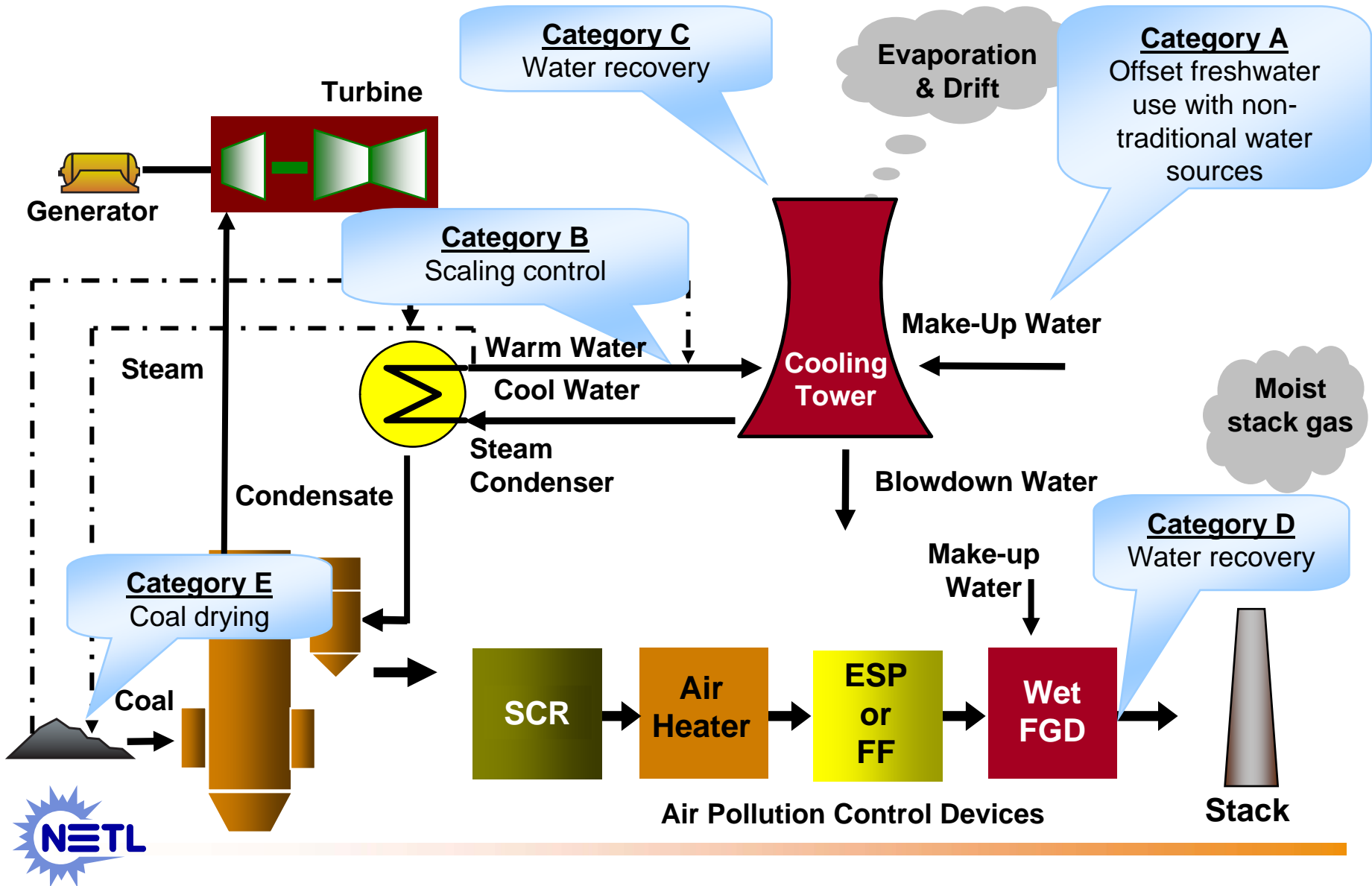


Overview of Regional Results: Case 2 (2005 – 2030) by Western Electricity Coordinating Council (WECC)

- **EIA thermoelectric capacity projections:**
 - 47% increase in California
 - 50% increase in Northwest Power Pool
 - 48% increase in Rocky Mountains
- **Case 2 withdrawal projections:**
 - 3% decrease in California
 - 32% increase in Northwest Power Pool
 - 38% decrease in Rocky Mountains
- **Case 2 consumption projections:**
 - 352% increase in California
 - 66% increase in Northwest Power Pool
 - 74% increase in Rocky Mountains

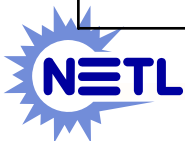


FE/NETL IEP Water Technology Categories



IEP Energy-Water Technology Categories & Current Projects

Category	Description
A	<p><u>Provide Alternate Source of Cooling Water Make-up</u></p> <ul style="list-style-type: none"> • Use of Produced Water in Recirculated Cooling Systems at Power Generation Facilities & Development of an Impaired Water Cooling System • Development and Demonstration of a Modeling Framework for Assessing the Efficacy of Using Mine Water for Thermoelectric Power Generation • Reuse of Treated Internal or External Wastewaters in the Cooling Systems of Coal-Based Thermoelectric Power Plants
B	<p><u>Increase Cycles of Concentration for Wet Recirculating Systems, thereby Decreasing Wet Cooling Tower Blowdown Requirements</u></p> <ul style="list-style-type: none"> • A Synergistic Combination of Advanced Separation and Chemical Scale Inhibitor Technologies for Efficient Use of Impaired Water as Cooling Water in Coal-Based Power Plants • Application of Pulsed Electrical Fields for Advanced Cooling in Coal-Fired Power Plants
C	<p><u>Advanced Cooling Technology</u></p> <ul style="list-style-type: none"> • Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants
D	<p><u>Reclaim Water from Combustion Flue Gas for Use as Cooling Water Make-up</u></p> <ul style="list-style-type: none"> • Water Extraction from Coal-Fired Power Plant Flue Gas • Recovery of Water from Boiler Flue Gas • Reduction of Water Use in Wet FGD System
E	<p><u>Reduce Cooling Tower Evaporative Losses via Coal Drying</u></p> <ul style="list-style-type: none"> • Use of Coal Drying to Reduce Water Consumed in Pulverized Coal Power Plants

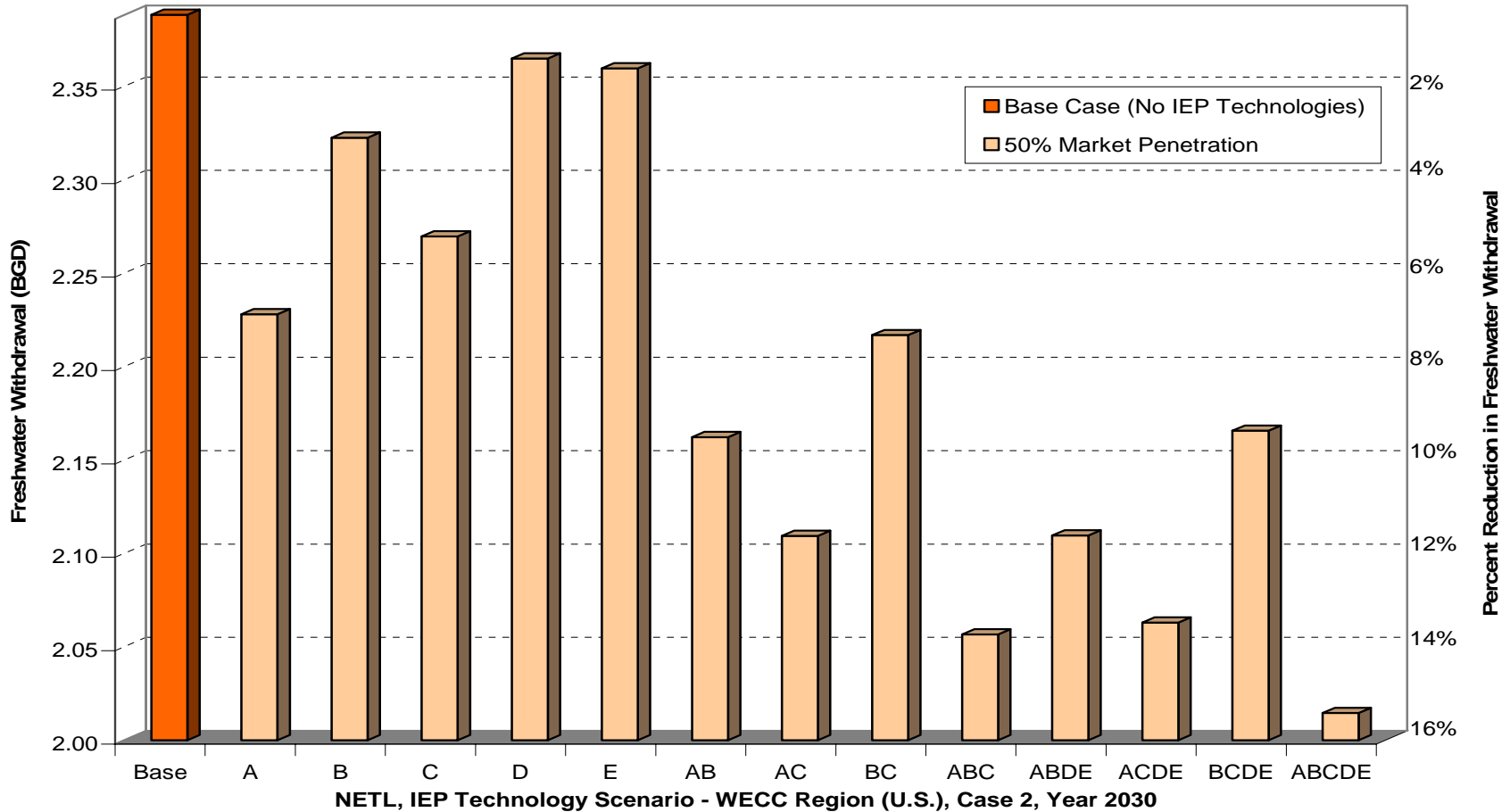


Technical & Cost Goals

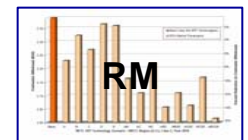
- **Short Term – Have technologies ready for commercial demonstration by 2015 that, when used alone or in combination, can reduce freshwater withdrawal and consumption by 50% or greater for thermoelectric power plants equipped with wet recirculating cooling technology at levelized cost of less than \$2.40 per 1000 gallons freshwater conserved.**
- **Long Term – Have technologies ready for commercial demonstration by 2020 that when used in combination can reduce freshwater withdrawal and consumption by 70% or greater at levelized cost of less than \$1.60 per 1000 gallons freshwater conserved.**



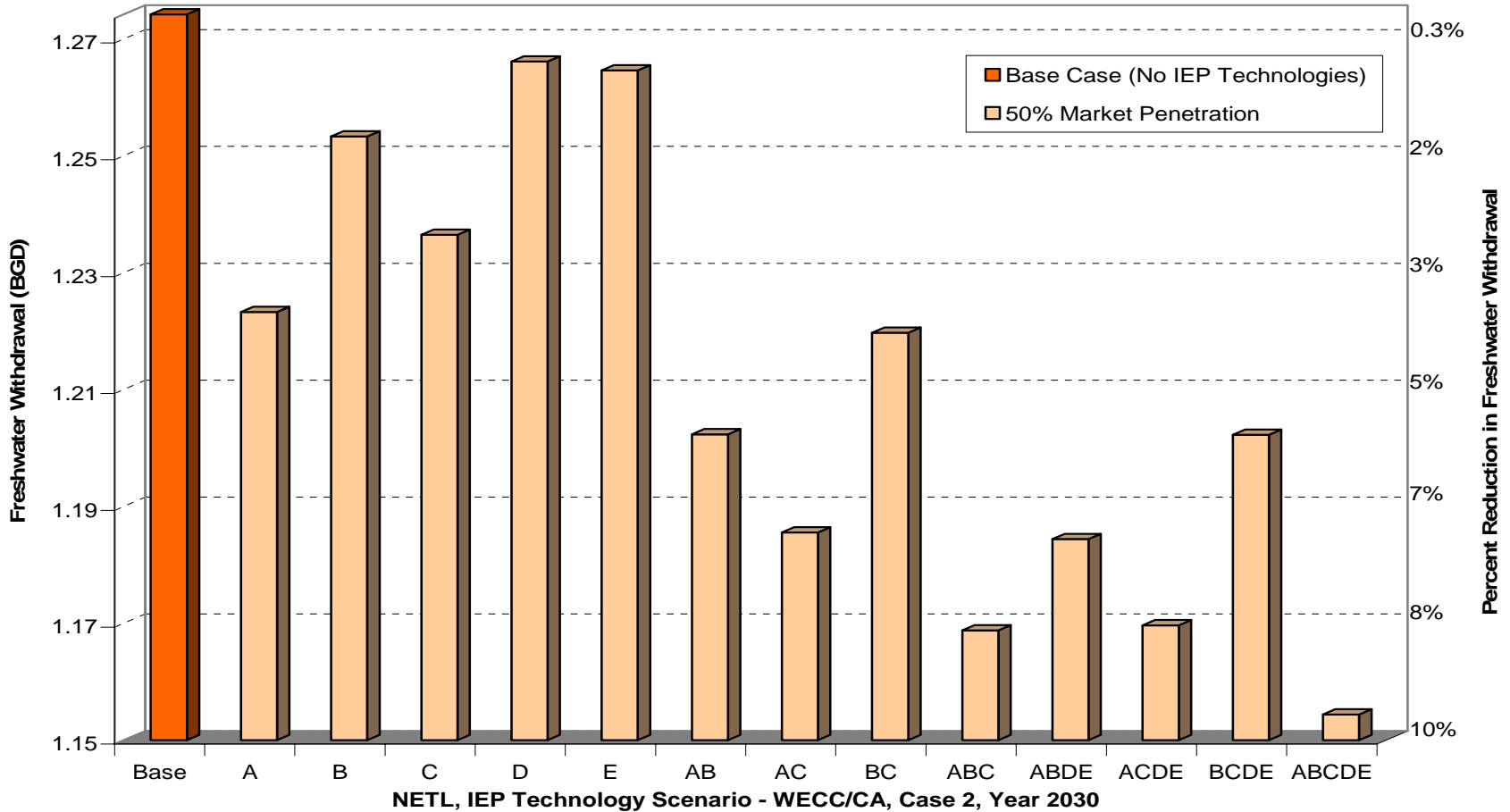
WECC Region (U.S.) Water Withdrawal with IEP Program Technologies



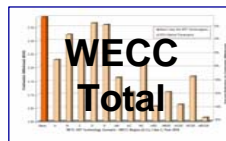
WECC Regional Results:



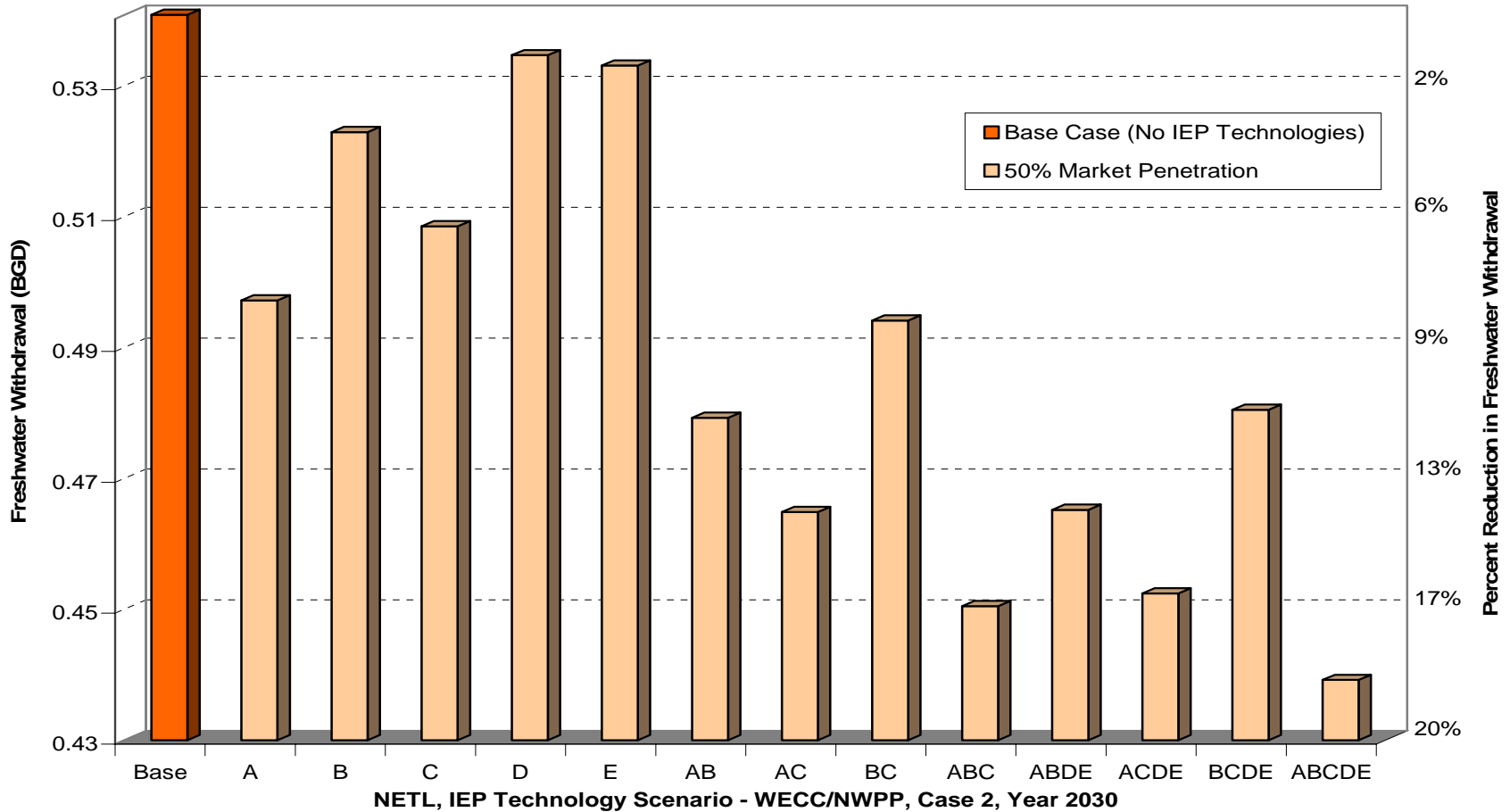
WECC/California Water Withdrawal with IEP Program Technologies



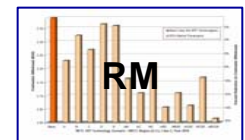
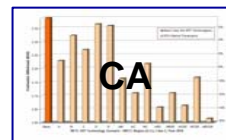
WECC Regional Results:



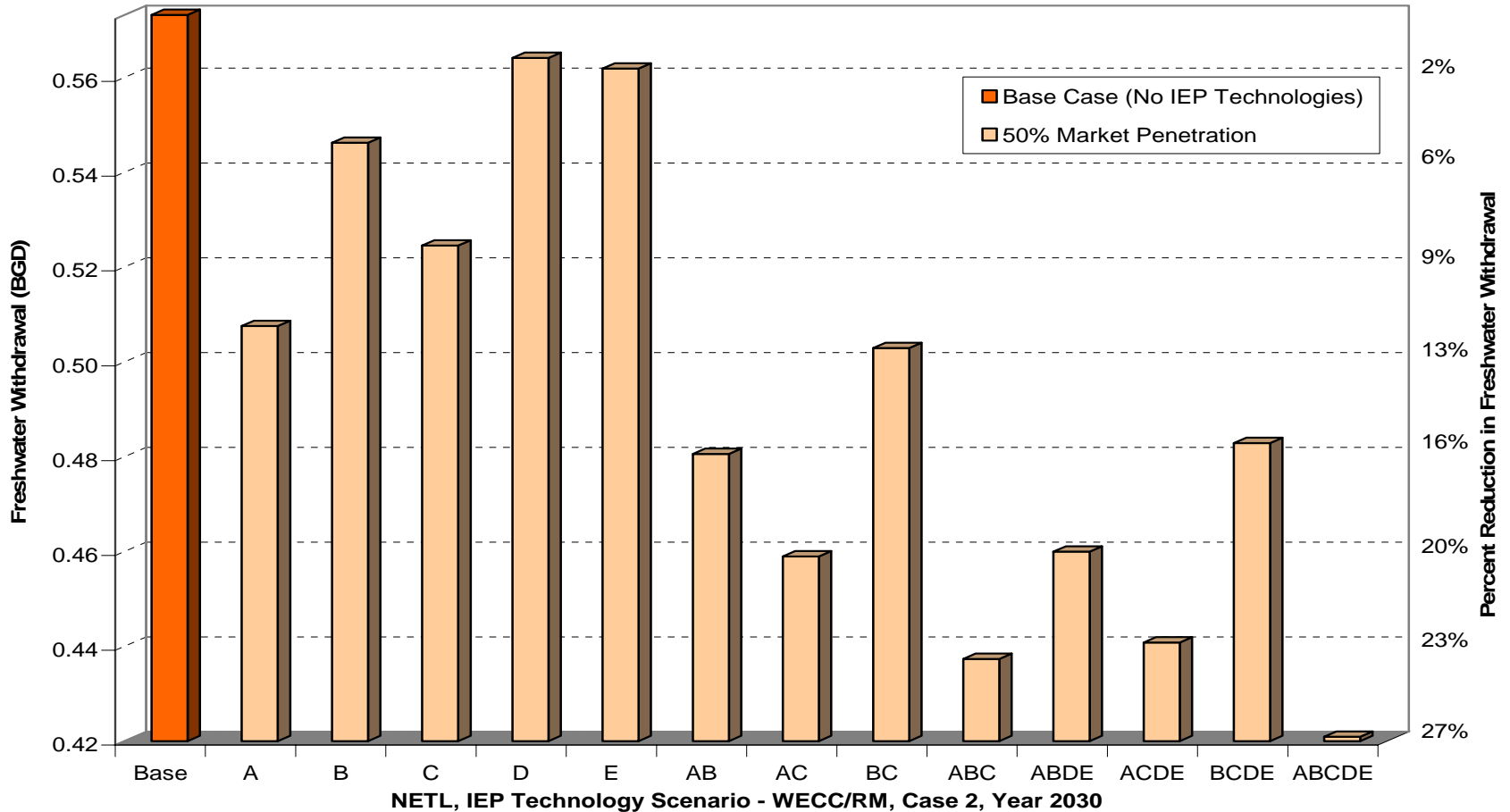
WECC/Northwest Power Pool Water Withdrawal with IEP Program Technologies



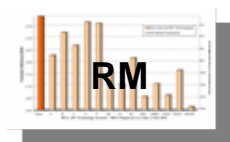
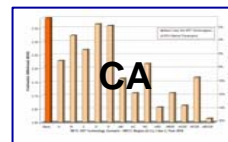
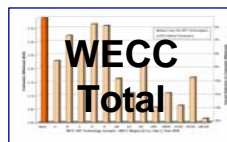
WECC Regional Results:



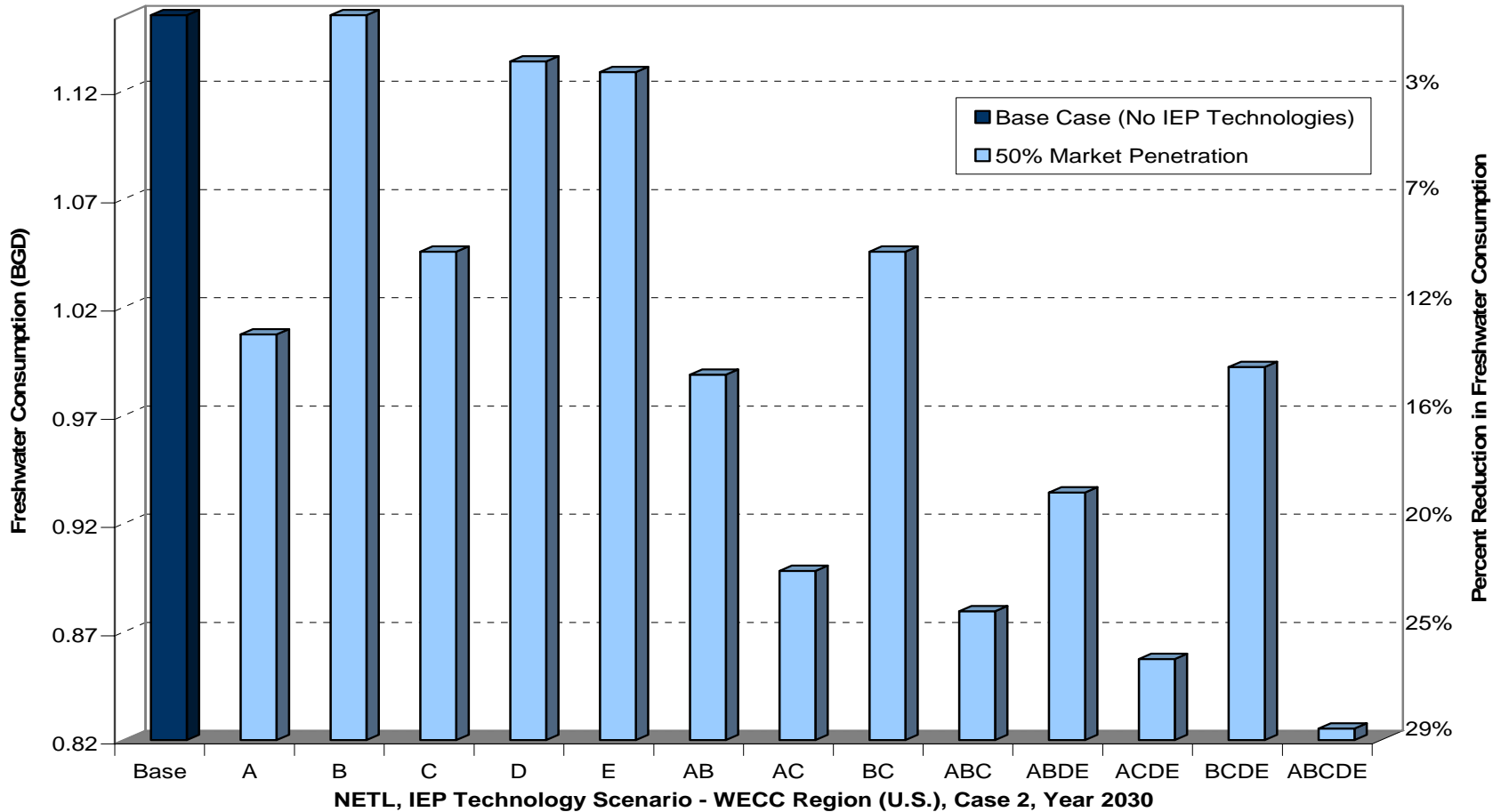
WECC/Rocky Mountain Water Withdrawal with IEP Program Technologies



WECC Regional Results:



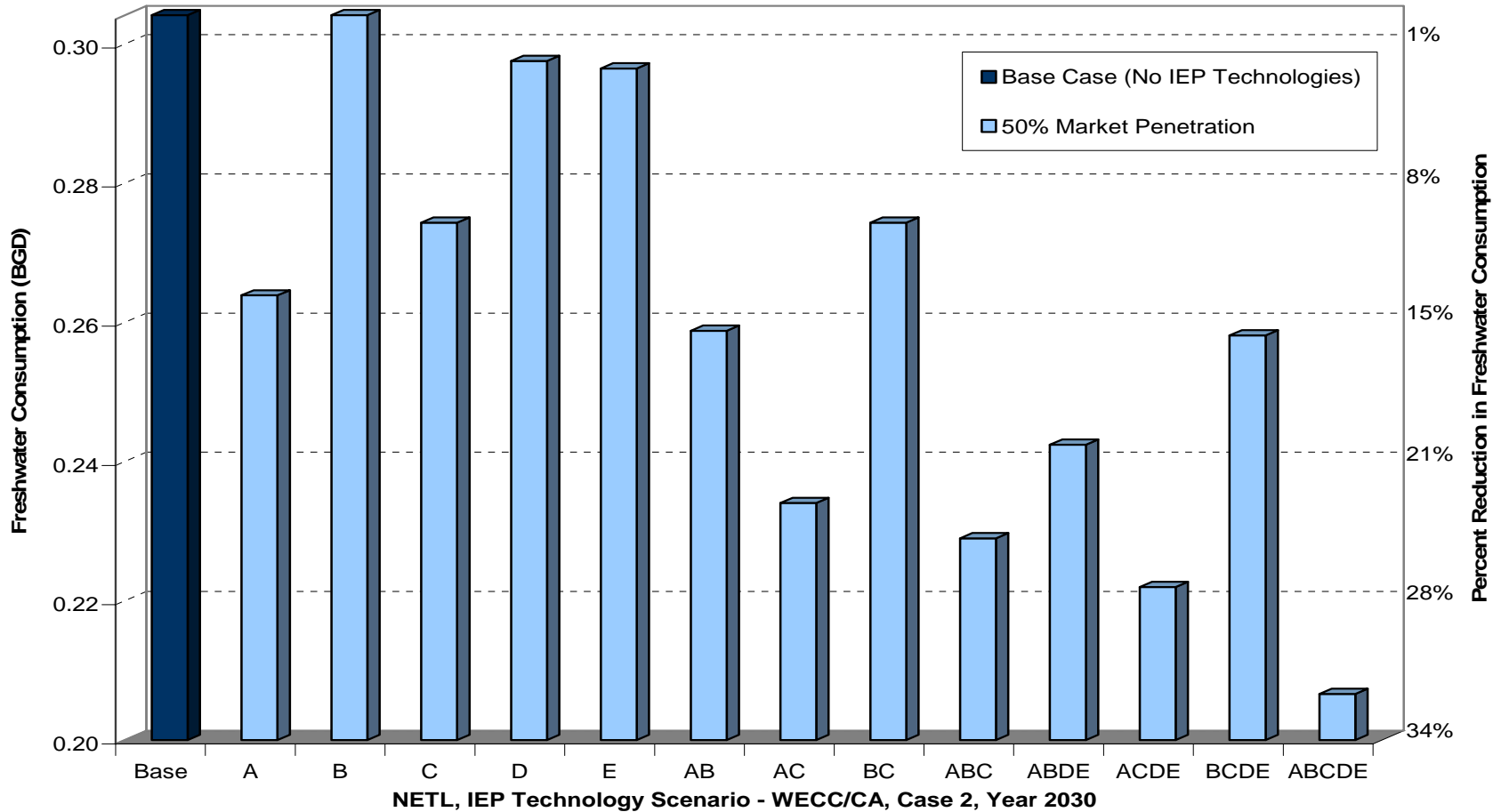
WECC Region (U.S.) Water Consumption with IEP Program Technologies



WECC Regional Results:



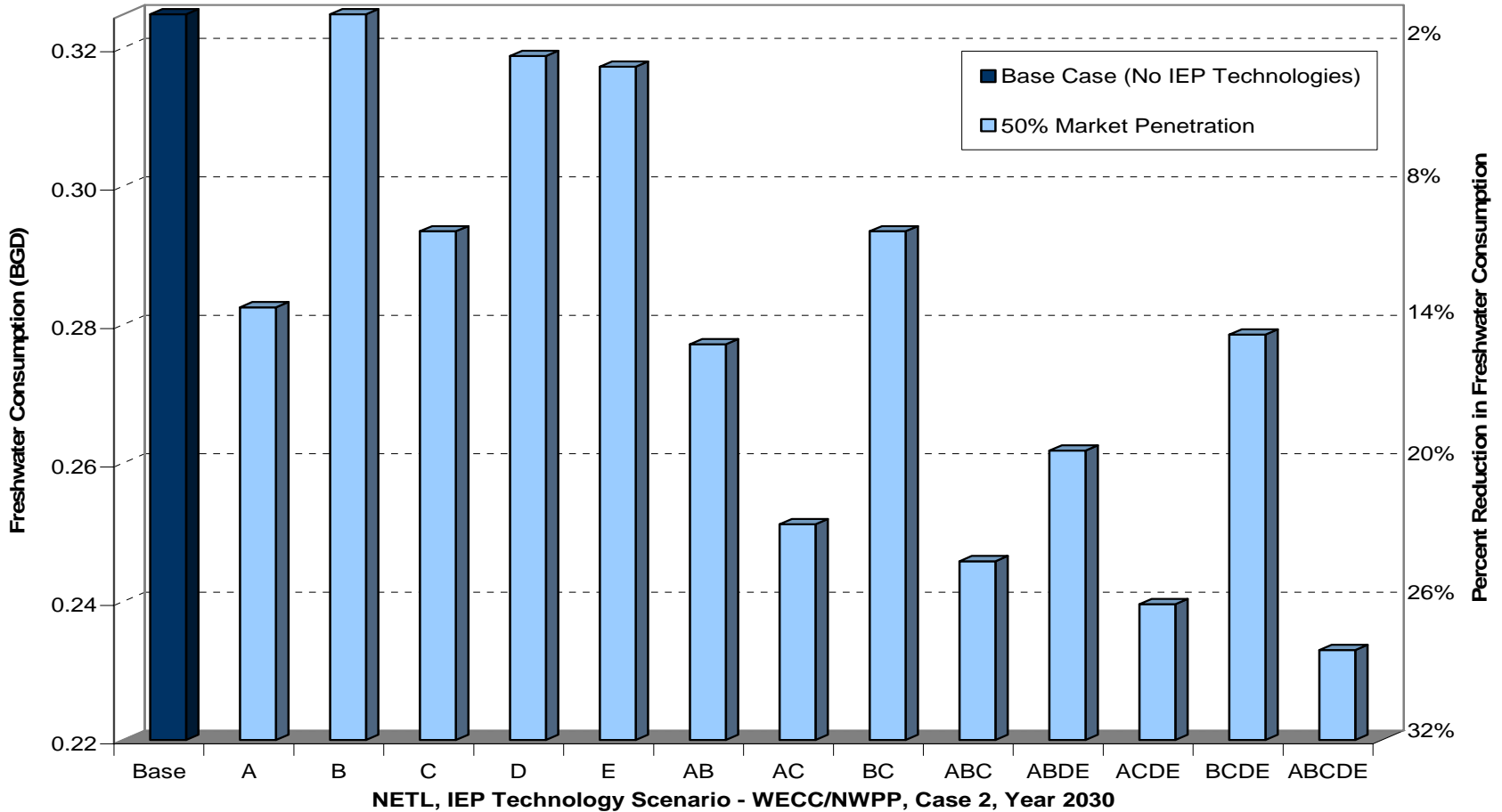
WECC/California Water Consumption with IEP Program Technologies



WECC Regional Results:



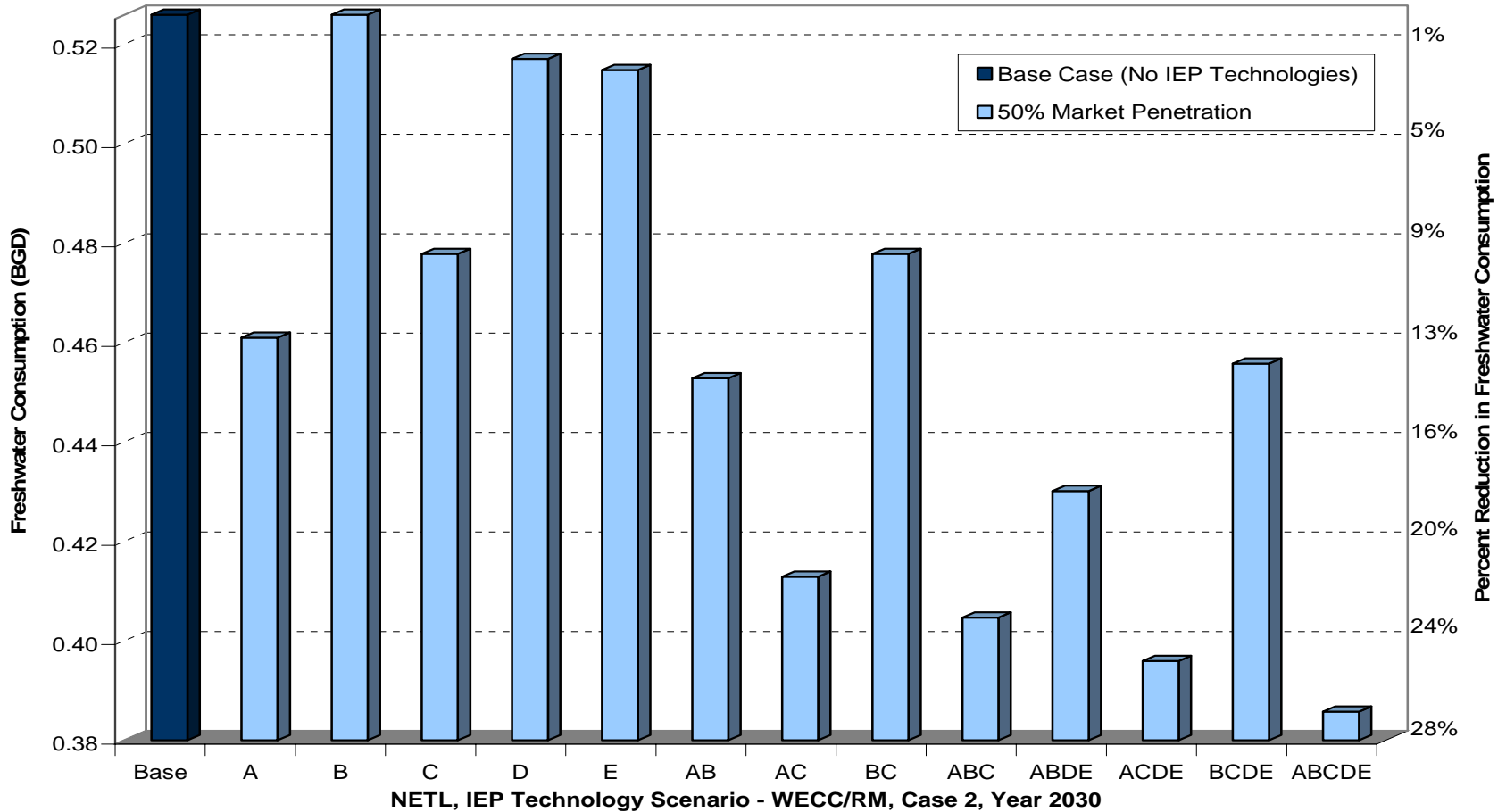
WECC/Northwest Power Pool Water Consumption with IEP Program Technologies



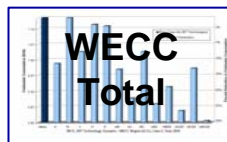
WECC Regional Results:



WECC/Rocky Mountain Water Consumption with IEP Program Technologies



WECC Regional Results:



Summary of Potential IEP Energy-Water Technology Benefits to WECC Region

- **WECC Region**
 - Withdrawal: 28.5% decrease (0.42 million a-f/yr)
 - Consumption: 15.7% decrease (0.37 million a-f/yr)
- **WECC/California**
 - Withdrawal: 9.4% decrease (0.13 million a-f/yr)
 - Consumption: 32.1% decrease (0.11 million a-f/yr)
- **WECC/Northwest Power Pool**
 - Withdrawal: 18.8% decrease (0.11 million a-f/yr)
 - Consumption: 28.3% decrease (0.10 million a-f/yr)
- **WECC/Rocky Mountain**
 - Withdrawal: 26.6% decrease (0.17 million a-f/yr)
 - Consumption: 26.7% decrease (0.16 million a-f/yr)

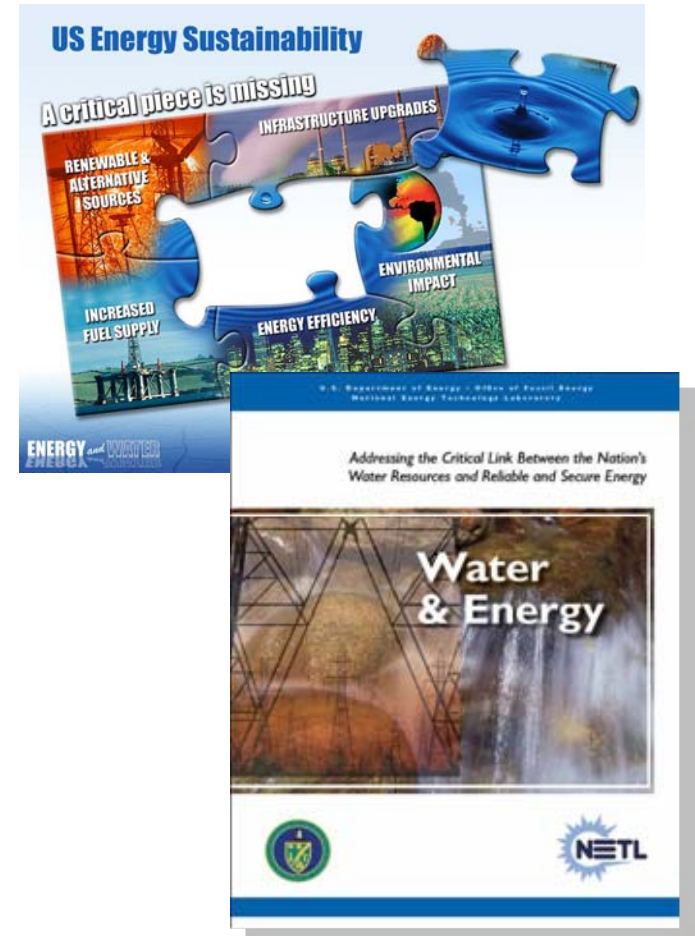
Projected benefits for Case 2, Year 2030, with a 50% Market Penetration.
Values represent the maximum potential from the array of technology scenarios.

[a-f/yr = acre-feet per year]



Summary

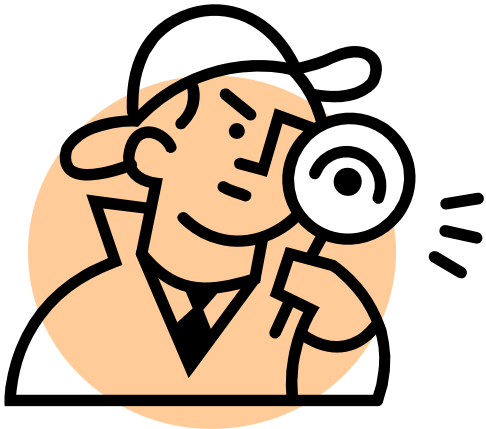
- Water-related issues will continue to challenge siting of new and/or operation of existing thermoelectric power plants
- These issues may become more critical in future due to competing demands, population growth, and increased energy demands
- In response, NETL will:
 - Update our analyses of water needs related to thermoelectric generation and coal, oil and natural gas production
 - Continue research and development of advanced water management technologies and concepts
 - Continue to work with/support Energy-Water Nexus team



**FE/NETL Energy-Water
Program Plan**



To Find Out More About NETL's Energy-Water R&D



NETL: Water - Energy Interface - Microsoft Internet Explorer

National Energy Technology Laboratory

Site Map

NETL

THE ONLY U.S. NATIONAL LABORATORY DEVOTED TO FOSSIL ENERGY TECHNOLOGY

- ABOUT NETL
- KEY ISSUES & MANDATES
- ONSITE RESEARCH
- TECHNOLOGIES**
 - Oil & Natural Gas Supply
 - Coal & Power Systems
 - Clean Coal Demonstrations
 - Environmental & Water
 - Gasification
 - Turbines
 - Combustion Technologies
 - Fuel Cells
 - FutureGen
 - Advanced Research
 - Contacts
 - Carbon Sequestration
 - Hydrogen & Clean Fuels
 - Technology Transfer

Environmental and Water Resources
Water - Energy Interface

Water and energy are inextricably linked. Because thermoelectric generation and fossil fuel extraction can impact water resources, it is critically important to protect U.S. water supplies while providing the energy needed to power the nation into the 21st century. Through integrated water and energy-related activities, the Department of Energy/National Energy Technology Laboratory (DOE/NETL) **Water-Energy Interface** is responding to this challenge through the development and application of advanced technologies and supporting science.

- Power Plant Water Management
 - Systems Analysis & Policy Support
 - Regulatory Drivers
 - In-House Watershed Science & Technology R&D
- Freshwater Needs Projected for Future Fleet [PDF-1.05MB]
- June 20, 2006, Water and Power Plant Overview [PDF-14.4MB]
- Updated NETL's Energy-Water RD&D Activities Brochure [PDF-638KB]

<http://www.netl.doe.gov/technologies/coalpower/ewr/water/index.html>



Questions?

