

# Responding to Emerging Power Plant-Water Issues – DOE/NETL's R&D Program

## *EPRI Environmental Sector Meetings*

*Boston, MA*

*September 27-October 1, 2004*



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# Presentation Outline

- **Background**
- **Freshwater Needs Analysis**
- **DOE/NETL R&D program**
- **Conclusion/future plans**

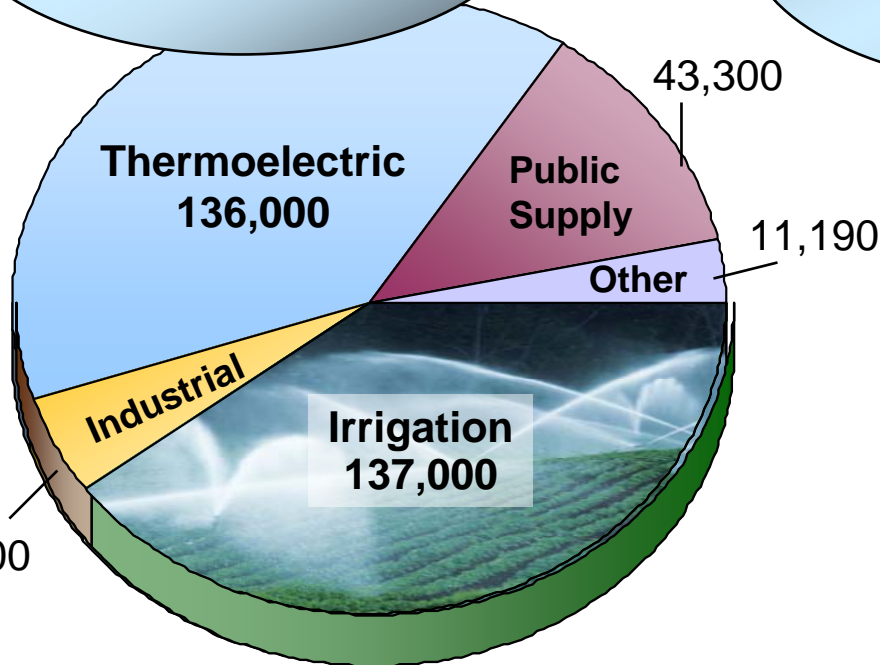


# Freshwater Withdrawals and Consumption

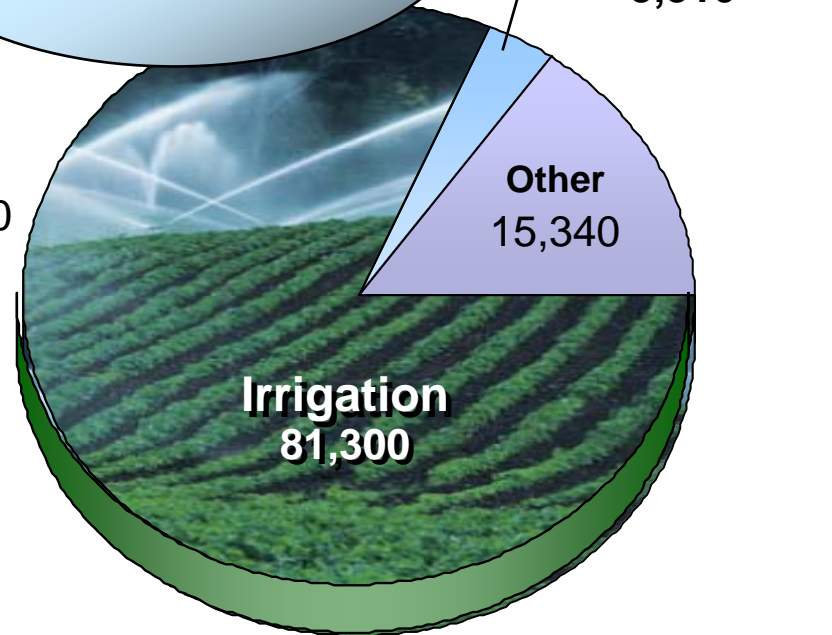
## *Mgal / Day*

Thermoelectric accounts for ~ 39% of withdrawals

Thermoelectric accounts for ~3% of consumption



**Withdrawal**



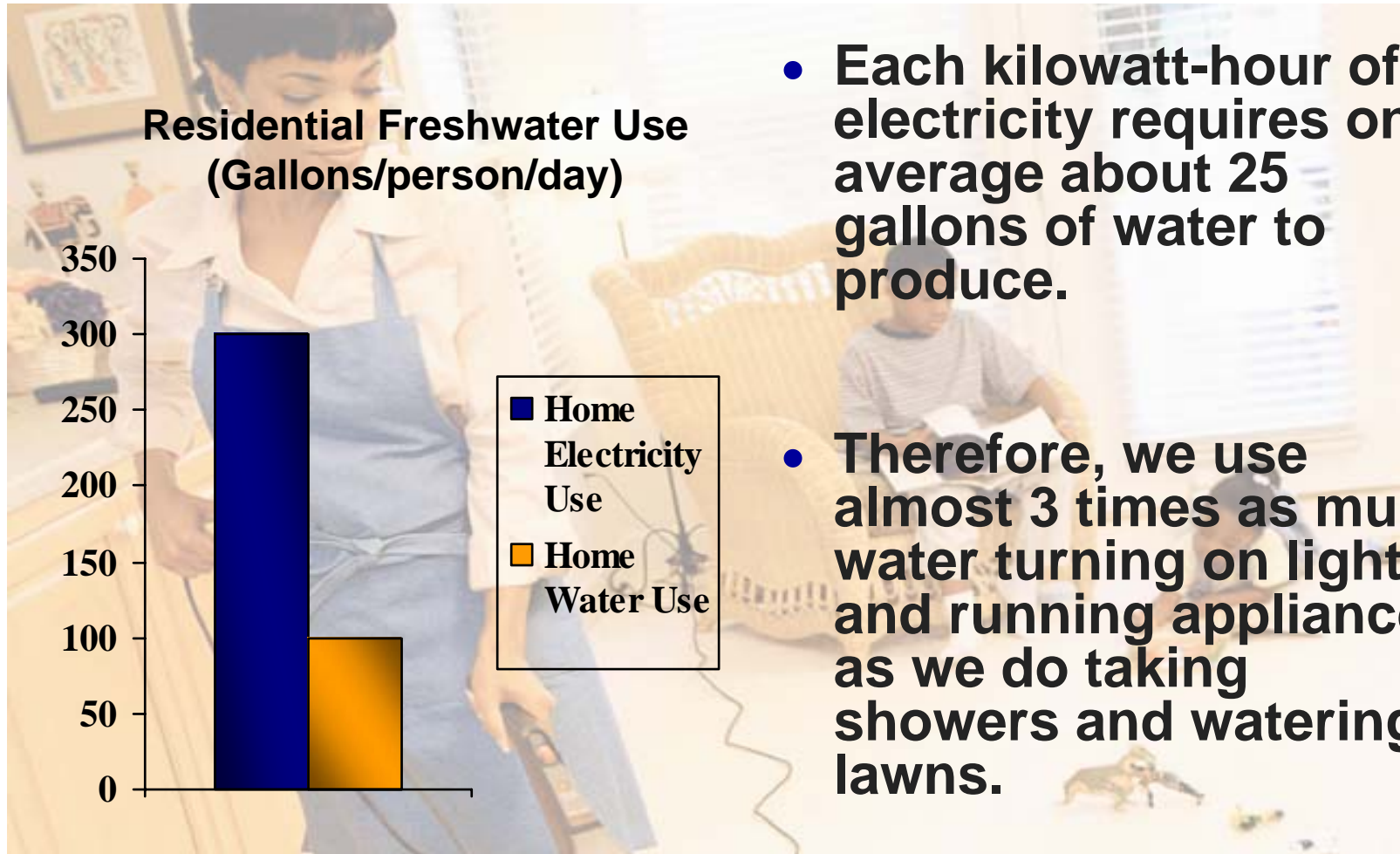
**Consumption**



Ref.: "Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998

"Estimated Use of Water in the United States in 2000," USGS Circular 1268, March 2004

# Water and Electricity Are Inextricably Linked



# Estimating Freshwater Needs to Meet 2025 Generating Capacity Forecasts

**NETL conducted an analysis in May 2004 to estimate the demand thermoelectric power plants will have on freshwater resources through 2025 using EIA's 2004 Annual Energy Outlook's reference case forecast for thermoelectric generating capacity.**



# Assumptions

- All new facilities will use closed loop re-circulating systems (wet cooling tower)
- Cooling system water needs considered approximate and do not vary depending on geographic location or source water-body characteristics
- All retirements equipped with once-through cooling systems



# Cooling System Water Needs

Fuel Source	Technology	Withdrawal (gal/kWh)	Consumption (gal/kWh)
Fossil	Once-Through	37.7	0.1
	Re-circ (Wet Tower)	1.2	1.1
Nuclear	Once-Through	46.2	0.1
	Re-circ (Wet Tower)	1.5	1.5

Consumption represents evaporation through heat loss

Source: EPRI *Water & Sustainability (Volume 3): U.S. Water Consumption For Power Production, The Next Half Century*, March 2002



# Projected Additions in Generating Capacity, GW

Cumulative Power Capacity Additions, GW (1995 Baseline)							
Year	1995	2001	2002	2010	2015	2020	2025
Coal Steam	0	5.8	6.0	12.8	24.6	57.8	117.7
Other Fossil Steam	0	0	0	0	0	0	0
Combined Cycle	0	50.8	95.7	145.3	177.0	202.7	220.6
Nuclear	0	0	0.5	2.4	3.9	4.4	4.4
<b>Total</b>	<b>0</b>	<b>56.6</b>	<b>102.2</b>	<b>160.5</b>	<b>205.5</b>	<b>264.9</b>	<b>342.7</b>

Ref. EIA, *Annual Energy Outlook 2004 with Projections to 2025*, January 2004. 1995 data, EIA, *Annual Energy Outlook 1997 with Projections to 2015*, December 1996





# Projected Generating Capacity Retirements, GW

Cumulative Power Retirements, GW (1995 Baseline)							
Year	1995	2001	2002	2010	2015	2020	2025
Coal Steam	0	0	0	7.5	8	9.2	10.3
Other Fossil Steam	0	4.7	6.0	33.5	36.9	38.5	43.1
Combined Cycle	0	0	0	0	0	0.1	0.1
Nuclear	0	1.0	1.0	1.0	1.0	1.0	1.0
<b>Total</b>	<b>0</b>	<b>5.7</b>	<b>7.0</b>	<b>42.0</b>	<b>45.9</b>	<b>48.8</b>	<b>54.5</b>

Ref. EIA, *Annual Energy Outlook 2004 with Projections to 2025*, January 2004. 1995 data, EIA, *Annual Energy Outlook 1997 with Projections to 2015*, December 1996



# Six Thermoelectric Capacity Addition/Retirement Scenarios Evaluated

<u>Case</u>	<u>Additions</u>	<u>Retirements</u>
1	Freshwater	Freshwater
2	70% Fresh/30% Saline	70% Fresh/30% Saline
3	Saline	Saline
4	Fresh	Saline
5	Saline	Fresh
6	Reduced by Repowering	None (Repowering)

# Projected Power Sector Freshwater Withdrawals

Freshwater Withdrawals, billion gallons/day							
	1995	2001	2002	2010	2015	2020	2025
Case 1	132.1	131.0	131.1	120.0	119.8	119.6	119.2
Case 2	132.1	131.1	131.4	123.6	123.5	123.3	123.1
Case 3	132.1	132.1	132.1	132.1	132.1	132.1	132.1
<b>Case 4</b>	<b>132.1</b>	<b>132.5</b>	<b>133.0</b>	<b>134.2</b>	<b>135.2</b>	<b>136.4</b>	<b>137.9</b>
Case 5	132.1	130.6	130.2	117.9	116.6	115.3	113.4
Case 6	132.1	132.4	132.7	133.3	134.6	135.6	136.8
Max	132.1	132.5	133.0	134.2	135.2	136.4	137.9
Min	132.1	130.6	130.2	117.9	116.6	115.3	113.4

**Greatest withdrawal for Case 4, least for Case 5**



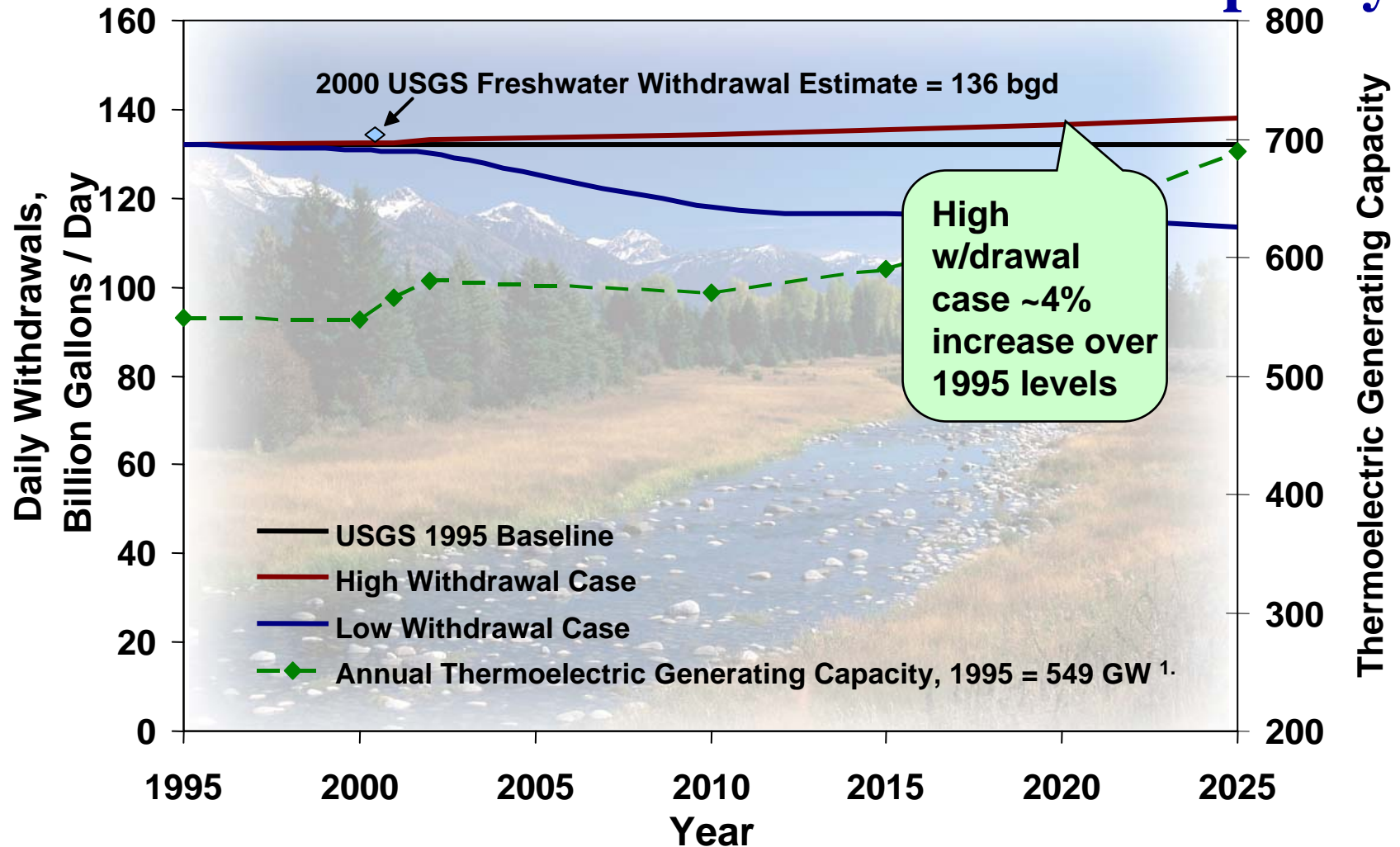
# Projected Power Sector Freshwater Consumption

Freshwater Consumption, billion gallons/day							
	1995	2001	2002	2010	2015	2020	2025
Case 1	3.3	3.7	4.1	5.2	6.2	7.3	8.7
Case 2	3.3	3.6	3.9	4.7	5.4	6.1	7.1
Case 3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
<b>Case 4</b>	<b>3.3</b>	<b>3.7</b>	<b>4.1</b>	<b>5.3</b>	<b>6.3</b>	<b>7.4</b>	<b>8.8</b>
Case 5	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Case 6	3.3	3.6	3.9	4.5	5.8	6.7	7.8
Max	3.3	3.7	4.1	5.3	6.3	7.4	8.8
Min	3.3	3.3	3.3	3.3	3.3	3.3	3.3

Greatest consumption for Case 4, least for Case 3,5



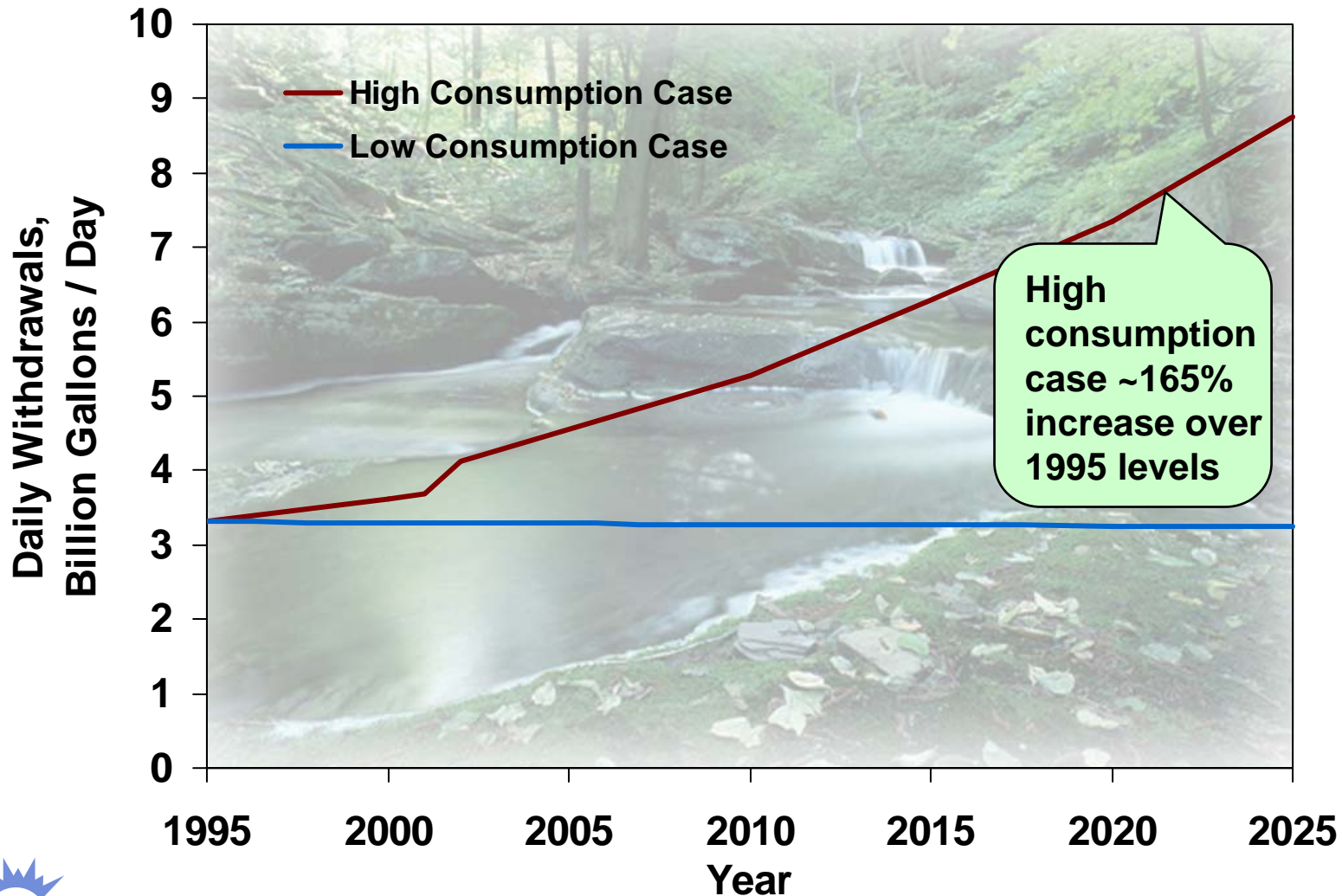
# Daily Freshwater Withdrawals Needed to Meet Forecasted Increases in Thermoelectric Capacity



Ref. DOE/NETL, "Estimating Freshwater Needs to Meet 2025 Electricity Generating Capacity Forecasts," June 2004.



# Projected Average Daily Water Consumption by Thermoelectric Power Generation



# Key Takeaways

- **Freshwater withdrawal in 2025 range from a 14% decrease to a 4% increase compared to 1995 levels**
- **Freshwater consumption in 2025 range from a 2% decrease to a 165% increase compared to 1995 levels**
- **Largest consumption, withdrawal increases were for case assuming all new plants use freshwater and all retired plants use saline (Case 4)**
- **Largest consumption, withdrawal decreases were for case assuming all new plants use saline and all retired plants use freshwater (Case 5)**
- **Thermoelectric power freshwater consumption, while increasing, still very small relative to other industries**



# Future Analysis

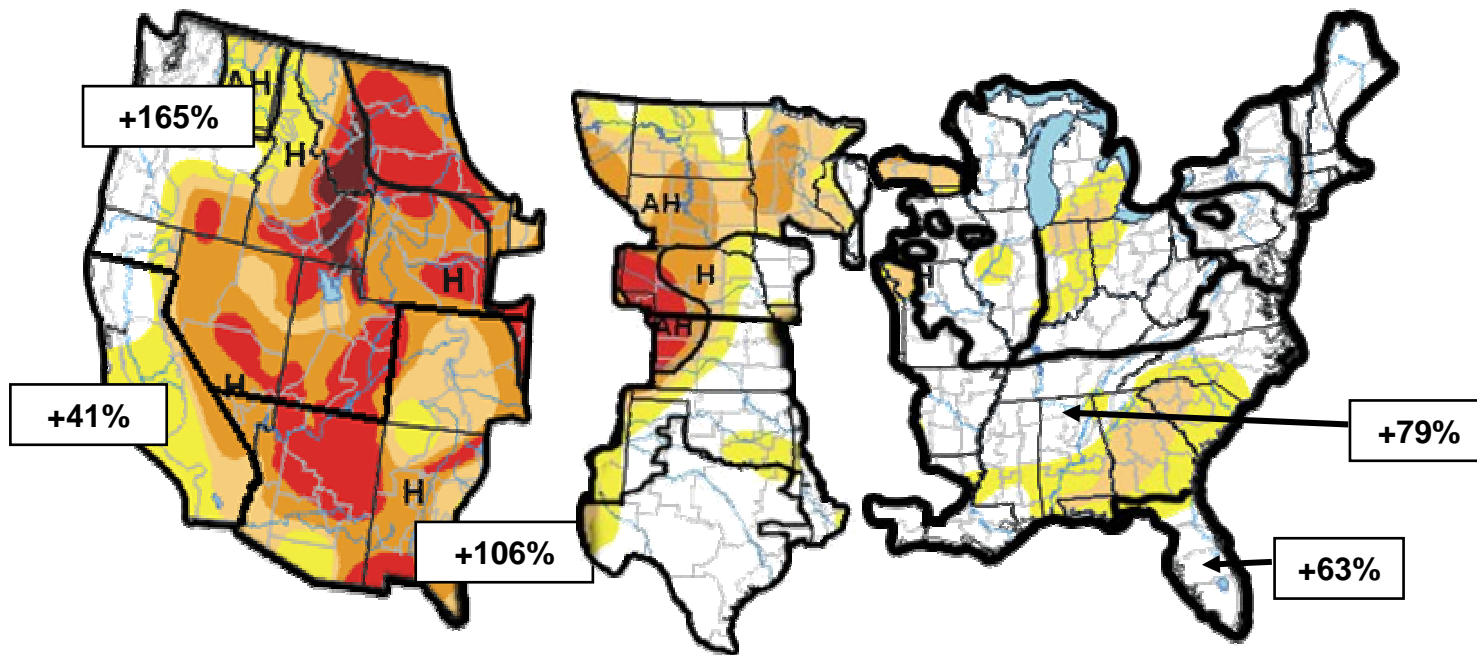
- Projected regional increases in thermoelectric capacity of 41-165% in western U.S, 63-79% in southeast U.S., by 2025
- Western and southeast U.S. already facing water availability issues
- Largest increases in population also projected in these areas
- Potential for conflict in several western cities as power generators compete with other water users

***NETL kicking off a regional freshwater needs assessment in October 2004***





# Drought Conditions Compared to 2025 Projected Regional Thermoelectric Generation Capacity Increases



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:

- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

**Regional thermoelectric generation capacity by North American Electric Reliability Council Region**

Sources: USDA and EIA



# Water Management Research Objectives<sup>1</sup>.

- Reduce withdrawal of fresh surface and/or ground water for thermoelectric power generation
- Minimize potential impacts of power plant operations (both air emissions and effluent discharges) on water quality

<sup>1</sup>DOE/CURC/EPRI “*Clean Coal Technology Roadmap,*” [www.netl.doe.gov](http://www.netl.doe.gov)



# Current DOE/NETL Water R&D Activities

- **Non-traditional process and cooling water**
- **Innovative water recovery and cooling technology**
- **Advanced cooling water intake technology**
- **Advanced pollutant measurement and treatment technology**

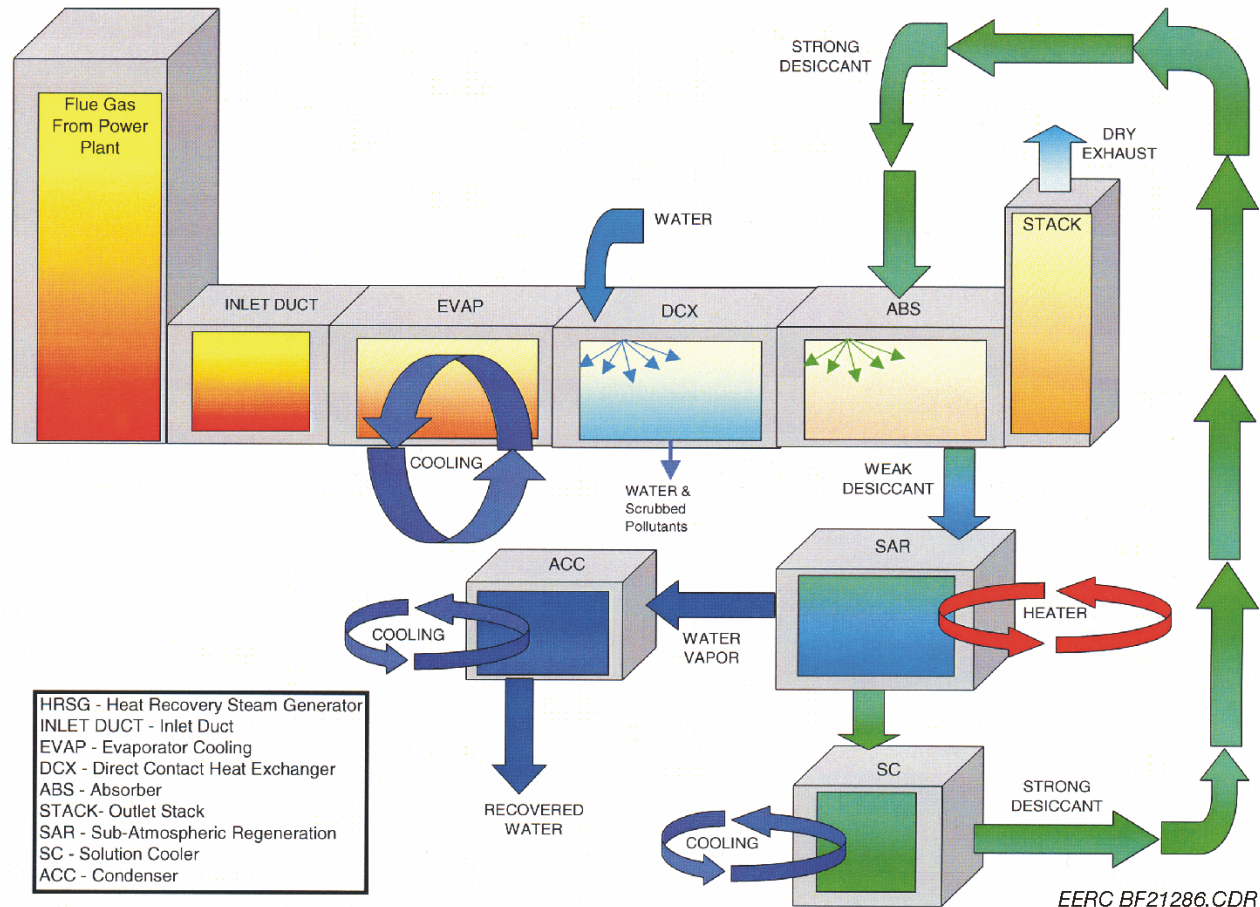


# Water Extraction from Coal-Fired Power Plant Flue Gas

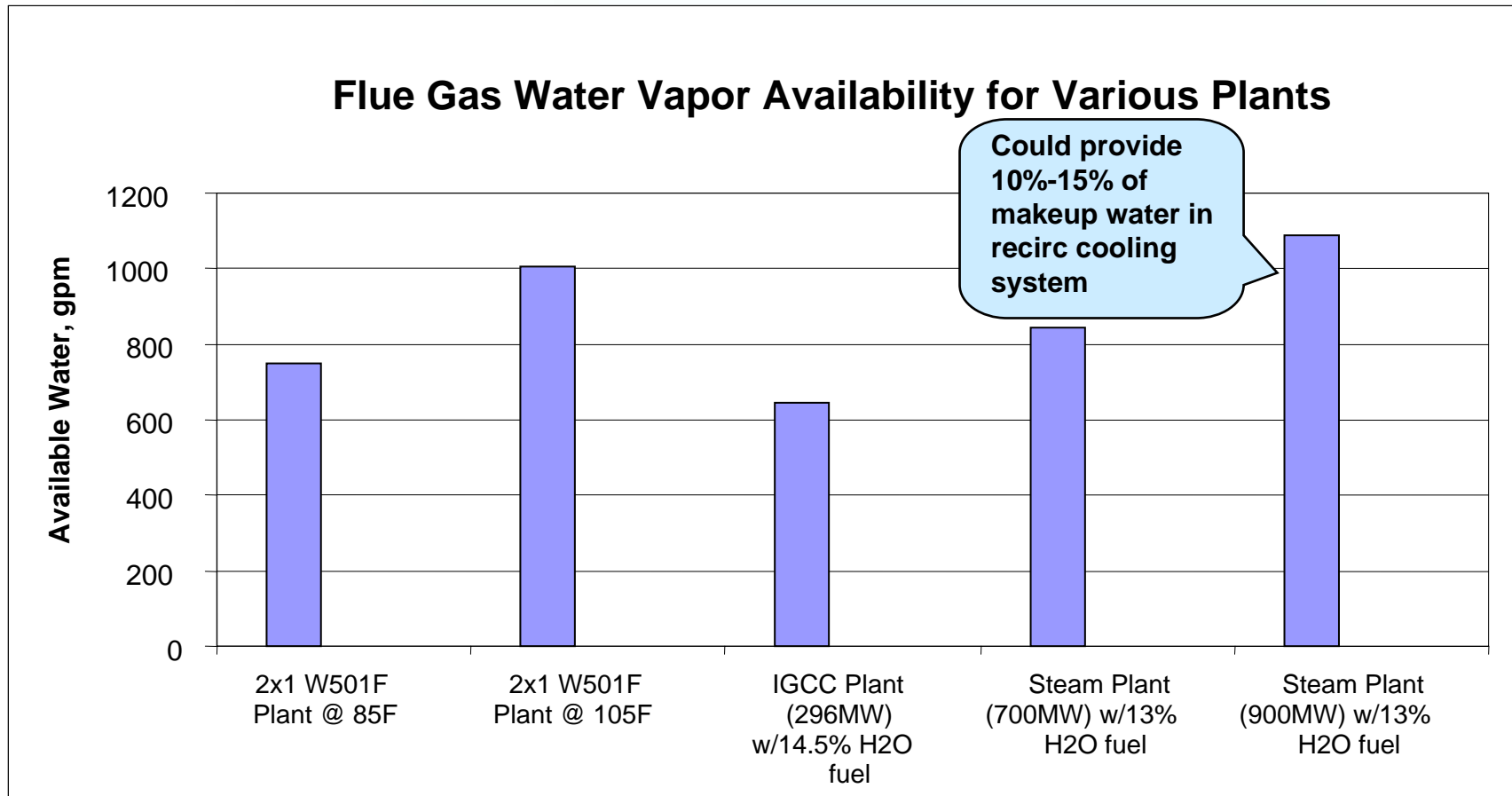


- **Energy & Environmental Research Center and Siemens Westinghouse Power Corporation**
- **Develop and test a desiccant-based dehumidification process that removes water from exhaust gas of fossil fuel-fired power plants**

# Desiccant-Based Water Recovery System



# How Much Water is Available in Flue Gas?



Source: University of North Dakota Energy & Environmental Research Center



# Use of Produced Water in Re-circulating Cooling Systems



***San Juan Generating Station***

- **EPRI and Public Service of New Mexico investigating ways to reduce freshwater withdrawals from San Juan River by as much as 17%**
- **Evaluate use of oil/gas produced water as cooling water for PNM's San Juan Generating Station**
- **Evaluate regulatory incentives and improved treatment and cooling technology**
- **Part of ZeroNet initiative to reduce overall freshwater use in New Mexico**

# Use of Produced Water in Re-circulating Cooling System

## *Summary Status*

- **Proposal for produced water reuse to be designated as an alternate method of disposal was passed in 2004 NM legislative session**
- **Proposal for tax credits to use produced water at power plant was not passed**
- **As result, PNM is evaluating a phased approach to use produced water at SJGS:**
  - Phase 1 - Building a new 11-mile pipeline to convey produced water from close-in production sites to SJGS
  - Phase 2 – Utilize existing CO<sub>2</sub> gas line to deliver produced water from 30 to 40 miles from SJGS



***San Juan River***



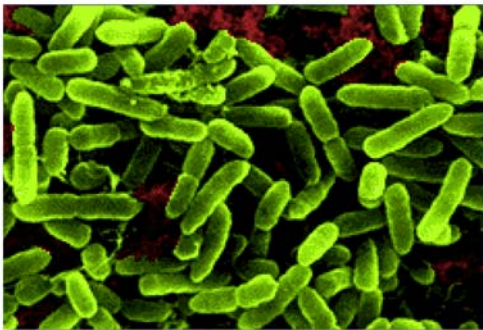
Ref. DOE, "Use of Produced Water in Recirculating Cooling Systems at Power Generating Facilities," August 2004



# Environmentally Safe Control of Zebra Mussel Fouling



*Zebra Mussels*



*Pseudomonas fluorescens*

- Rochester Gas & Electric partnership with NY State Education Dept
- Evaluate innovative methods to control bio-fouling of cooling water intake systems that incorporates selective toxins from a naturally-occurring bacterium

# Zebra Mussel Mortality

- Test results indicate both species are of near equal susceptibility to *Pseudomonas fluorescens*

<b>Mussel Mortality Recorded in Experiments</b>					
<b>Mussel populations</b>	<b>Bacterial treatment concentration (ppm)</b>	<b><i>D. polymorpha</i> Mean mortality (%)</b>		<b><i>D. bugensis</i> Mean mortality (%)</b>	
		<b>Small</b>	<b>Large</b>	<b>Small</b>	<b>Large</b>
<b>Lake Erie mussels</b>	<b>209</b>	<b>96.6</b>	<b>93.4</b>	<b>98.4</b>	<b>91.4</b>
<b>Lake Ontario mussels</b>	<b>177</b>	<b>84.8</b>	<b>83.5</b>	<b>88.4</b>	<b>92.9</b>

Ref. DOE Quarterly Technical Report, "Lethality of *Pseudomonas fluorescens* Strain CLO145A to Two Zebra Mussel Species Present in North American, July 1, 2001.





Pacific Northwest  
National Laboratory



# An 11 national laboratory effort to address a broader set of energy-water science & technology needs

THE **ENERGY** ~ **WATER** NEXUS

*a strategy for energy and water security*

# Summary

- **Water availability and quality, future regulations, and issues of public perception related to freshwater resources will challenge power plant design and operation**
- **DOE/NETL will continue to partner with industry, academia, and other key stakeholders to carry out research directed at freshwater management**
- **This program will help to maintain coal's strategic role in providing U.S. with secure, reliable, affordable, and environmentally sound energy while protecting our vital freshwater resources**



# Future Plans

- **Issue second power plant-water solicitation late FY05 (summer 2005) to expand NETL's water research program**
- **Continue to work with other DOE national laboratories and EPRI to implement broad energy-water RD&D program**





**“Whiskey is for drinking;  
water is for fighting.”**

**– Mark Twain**

Please visit our website at:  
[www.netl.doe.gov/coal/E&WR](http://www.netl.doe.gov/coal/E&WR)

