Holistic Environmental Management and Power Plant Water Use

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Topics

- Definitions and Technologies
- Holistic Environmental Management
- Climate Change Adaptation Energy Policy
- EPA Cooling System Regulations
- Thermal Power Plant Water Conservation Strategies

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Definitions and Technologies

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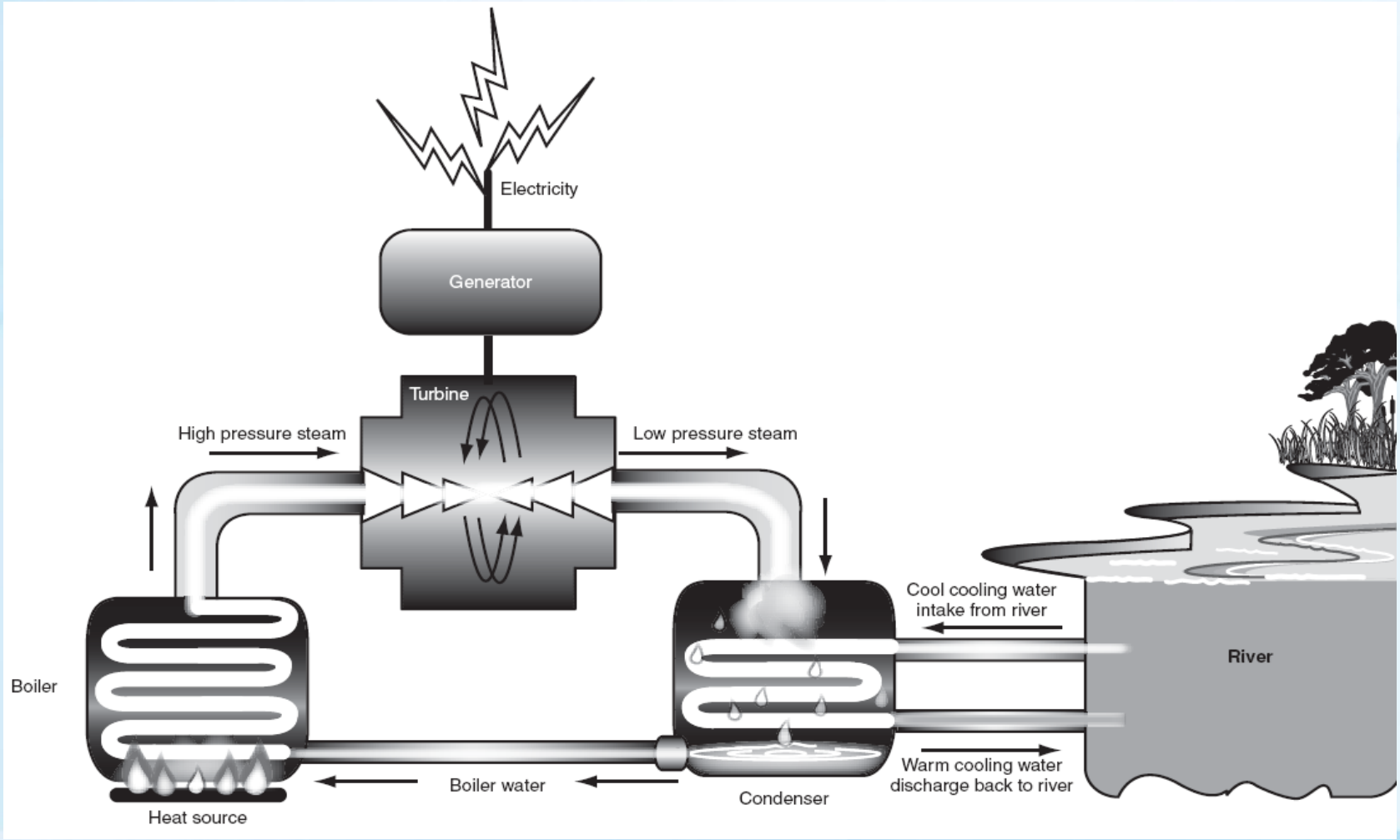
Water Use Definitions

- *Water Use* consists of two processes that can occur separately or in sequence.
- *Consumption*—water either ceases to exist as a liquid (evaporation) or is not fit to be returned directly to its original source (degradation)
- *Withdrawal*—water is removed from a source and may be consumed or returned in practically the same condition

Thermoelectric Power Plant Cooling Systems

- Steam that turns the turbine to produce electricity must be cooled back to water so that the cycle can continue
- Once-Through—cold water from waterbody circulates through the plant and is returned to the waterbody
- Wet Cooling Towers—circulating water from the plant moves through the tower and is cooled by evaporation

Once-Through Cooling System



Source: U.S. Government Accountability Office

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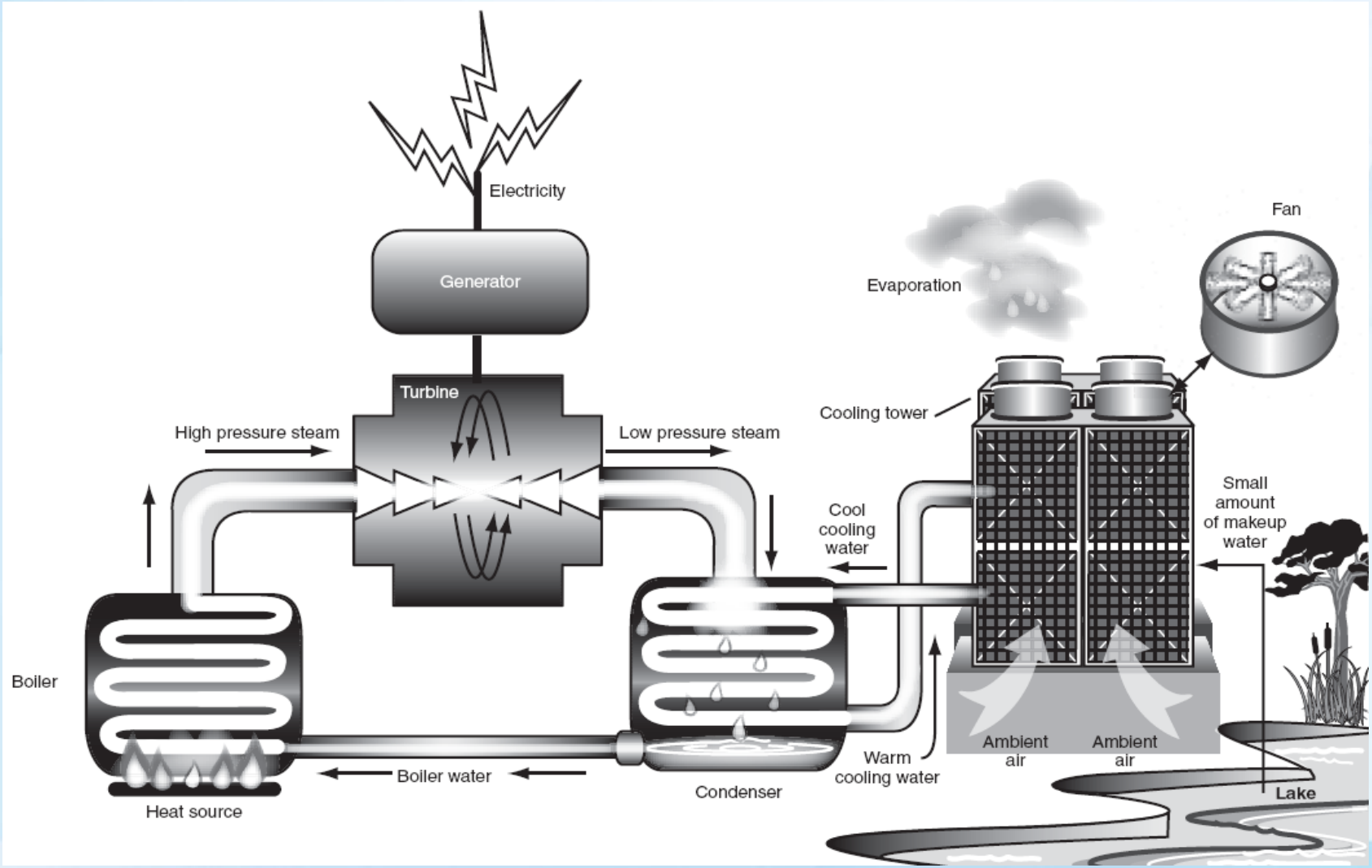
Cooling Towers



Source: U.S. Government Accountability Office

Holistic Environmental Management

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Policy Challenges—Interdependency

- Large-scale electricity generation and large-scale usable water production are interdependent
- Components of the environment are interrelated—alterations to one affect all others

Holistic Environmental Management

Consider Local Ecosystem, Balance Relationships, Make Responsible Trade-Offs

- Water Quantity
- Water Quality
- Aquatic Life
- Wildlife
- Land Use—Habitat
- Air Quality—Emissions
- Electricity Reliability
- Climate Change Mitigation
- Climate Change Adaptation
- Sustainable Development—
- Environmental Preservation
- Economics

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Water Quantity—Cooling Systems

- Once-through systems consume 1% of water withdrawn
- Cooling-tower systems consume 70%-90 % of water withdrawn
- Cooling tower systems consume twice as much water as once-through systems
- Cooling tower systems can consume as little as 1%-2% of annual river flow

Sources: EPRI; National Energy Technology Laboratory; National Renewable Energy Laboratory; SCE&G

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Water Consumption by Energy Source

Energy Source for Electricity Generation	Water Consumption Gallons/Megawatt-Hour	
Natural Gas	Once-Through Cooling	100
	Combined Cycle with Cooling Towers	370
Coal	Minimal Pollution Controls & Once-Through Cooling	300
	Advanced Pollution Controls & Wet Cooling Towers	714
Nuclear	Once-Through Cooling	400
	Wet Cooling Towers	720
Hydro		4,500
Geothermal		1,800-4,000
Biomass		300-480
Solar-Thermal		1,040
Solar Photovoltaic		30
Wind		1

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Sources: EPRI; National Energy Technology Laboratory; Peter Gleick

Aquatic Life—Once-Through Systems

- Scientific studies demonstrate that once-through systems do not have an adverse impact on aquatic life populations:

Power Plant	State
North Anna Power Station	Virginia
Salem Nuclear Station	New Jersey
Indian Point Energy Center	New York
Brunswick Nuclear Plant	North Carolina
Oconee Nuclear Station	South Carolina
Ohio River (15 plants, all fuels)	IN, KY, OH, PA, TN, WV

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Land Use—Habitat

Thermal Power Plant Land Use		
Peach Bottom (nuclear)	2,200 MW	400 acres
Millstone (nuclear)	1,900 MW	220 acres
West County (natural gas)	3,750 MW	220 acres
Mountaineer (coal)	1,300 MW	450 acres

Renewables Land Use Required to Generate Same Amount of Electricity as 1,000 MW Nuclear Plant	
Wind Farm	150,000-180,000 acres
Solar Park	54,000 acres

Sources: NRC License Renewal EISs; FPL; NETL; NEI calculation from AWEA data

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Air Quality—Emissions

- Nuclear plants during operations produce no NOx (ground level ozone), no SO_2 (acid rain), no CO_2 (climate change)
- Nuclear energy life-cycle CO_2 emissions are comparable to renewables
- Natural gas plants produce half the CO_2 emissions of coal plants
- Renewables such as wind and solar are emission-free

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Sustainable Development

Environmental Preservation and Economic Progress

(1) Environment

- Thermoelectric power plants account for 3.3% of U.S. freshwater consumption, half of residential consumption, at 6.7%
- Irrigation accounts for 81% of U.S. freshwater consumption
- Thermoelectric power plants return 98% of the water they withdraw

Source: U.S. Geological Survey (1995)

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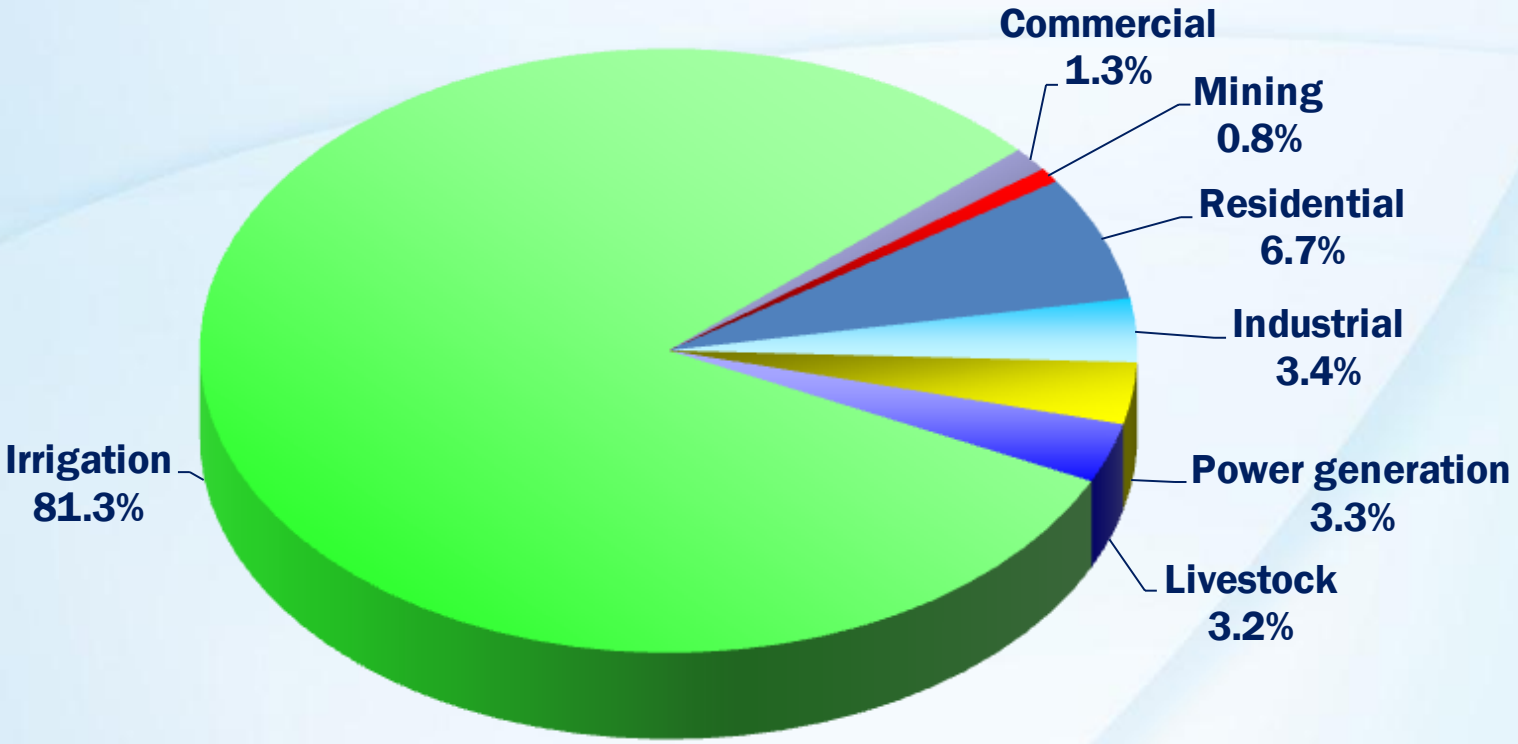
U.S. Water Consumption



Source: US Geological Survey (1995)

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Sustainable Development

Environmental Preservation and Economic Progress

(2) Economics

- Standard of living depends upon availability of usable water and electricity
- 87% of U.S. electricity is produced by thermoelectric power plants
- 80% of municipal water processing and distribution costs are for electricity
- 4% of U.S. electricity generation is used for water supply and wastewater treatment

Sources: U.S. Energy Information Administration; EPRI

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Climate Change Adaptation

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Climate Change and Electricity Generation
Thermal Power Plants

- Slightly elevated waterbody temperatures—output curtailed somewhat more frequently to meet discharge temperature limits
- Somewhat higher intake water temperatures—small decrease in operating efficiency
- STUDY: Michelle Vliet, et al. "Vulnerability of US and European Electricity Supply to Climate Change," *Nature Climate Change Letters*, June 3, 2012

Climate Change and Electricity Generation
Renewables—Reliability

- STUDY: National Renewable Energy Laboratory, *Renewable Energy Futures Study*, October 2012
- By 2050, U.S. grid with 80% renewables generation, 50% intermittent, resulting in 50% water consumption reduction
- Issue: grid stability

Assumptions	**Reality**
US Grid—Direct Current (DC)	US Grid—Alternating Current (AC)
Load Balancing—One Hour	Load Balancing—Continuous

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Climate Change and Electricity Generation Renewables—Supply (1)

- "Impacts projected but not well defined at this time"
- Wind and weather: increase in number of warm days, lengthening of summer season—less wind
- Solar and weather: more unsettled and stormy, increase in cloudy conditions—less sun
- STUDY: National Climate Assessment and Development Advisory Committee (NCADAC), Draft Report [*Climate Change and the American People*], January 14, 2013

Climate Change and Electricity Generation Renewables—Supply (2)

- "planetary waves almost freeze in their tracks for weeks"
- STUDY: Potsdam Institute for Climate Impact Research, "Quasiresonant Amplification of Planetary Waves and Recent Northern Hemisphere Weather Extremes," *Proceedings of the National Academy of Sciences*, March 1, 2013
- "PMP values will increase in the future "
- STUDY: National Oceanic and Atmospheric Administration (NOAA), "Probable Maximum Precipitation (PMP) and Climate Change, " *Geophysical Research Letters*, March 7, 2013

Climate Change and Energy Policy—Diverse Energy Portfolio

- All energy sources will be required—fossil, nuclear, renewables—as all have advantages and disadvantages
- Balance environmental, social, and economic factors and make responsible trade-offs
- Base decisions on site-specific analysis
- Research technology innovations to adapt all generation types to climate change

EPA Power Plant Cooling System Regulations

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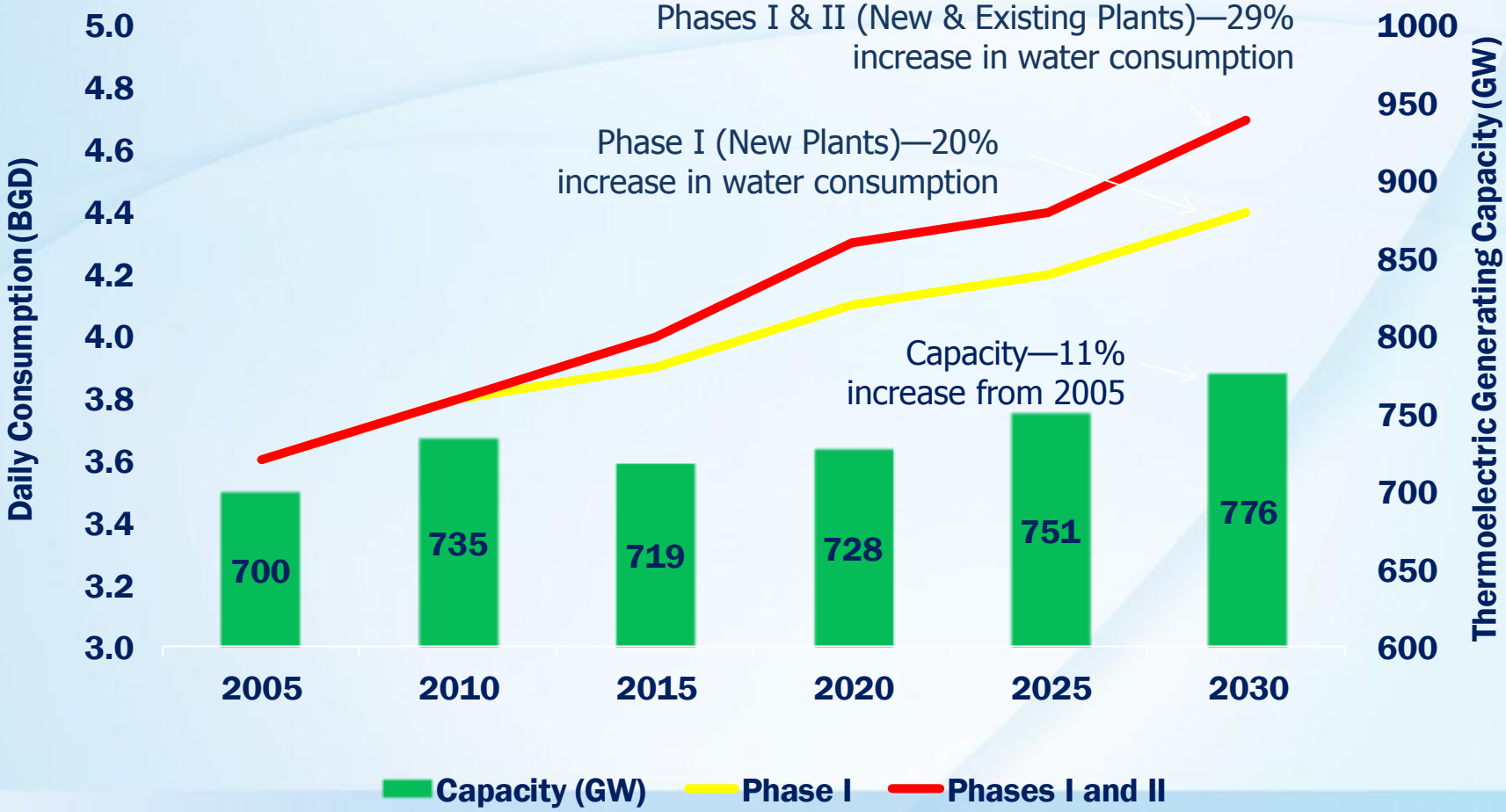
Projected Freshwater Consumption By Thermoelectric Power Generation Under EPA 316(b) Regulations



Source: National Energy Technology Laboratory

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EPA 316(b) New Plant Regulation from a Holistic Perspective — Climate Change Adaptation

- Climate change studies project an abundance of sea water, but citing new plants on coasts and estuaries will be very difficult
- CWA Section 316(b) Phase I (new plants) effectively requires cooling towers
- Cooling towers emit particulate matter and salt drift air pollution
- Clean Air Act and implementing regulations strictly limit these pollutants

EPA 316(b) Existing Plant Regulation from a Holistic Perspective— Entrainment Requirements

- State environmental agency determines best technology available for each site according to:
  - Organisms
  - Waterbody
  - Water Consumption
  - Air Pollution
  - Energy Reliability
  - Land Availability
  - Plant Life
  - Thermal Pollution
  - Cost-Benefit

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Impingement Requirements — Mortality Limit Developed Without Holistic Approach

Comparison of Data EPA Analyzed to Universe Affected by 316(b) Regulation		
Data Category	*EPA Analysis Based On:*	*Regulation Applies To:*
States	1	50
Facilities	3	1,152
Fish Species	15	3,153

Sources: EPA, *Technical Development Document for Proposed 316(b) Phase II Rule*, Exhibit 11-3; FishBase at www.fishbase.org

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Averaging Ensures Noncompliance of Half of BTA Performance Samples

Annual Impingement Measurements from Plants with BTA Used to Determine Annual Percentage Mortality Limit of 12 Percent		
Facility/Unit	***Percent Impingement Mortality***	***Status***
Arthur Kill, Unit 20	19.2%	Non-Compliance
Huntley	16.9%	
Averaging Results in Two of Four in Non-Compliance	**12%**	**Standard**
Arthur Kill, Unit 30	6.9%	Compliance
Dunkirk	5.5%	

Source: EPA, *Technical Development Document for Proposed 316(b) Phase II Rule*, Exhibit 11-5

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Thermal Power Plant
Water Conservation Strategies

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Municipal Wastewater Recycling
Palo Verde

- In the United States, 50 power plants use reclaimed water for cooling
- Palo Verde has used municipal wastewater for cooling since beginning operations in the 1980s
- Palo Verde is the largest power plant of any type in this country as measured by electricity production

Mine Pool Water Recycling
Limerick

- Mine pool water is released upstream in the main waterbody to supplement the river's flow during shortages
- Strategy significantly reduces freshwater consumption from natural water bodies

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Naturally Replenished Cooling Canals
Turkey Point

- All cooling handled by network of self-contained cooling canals
- Evaporative losses replenished by rainfall, plant storm water runoff, and treated process water
- No surface- or groundwater is used