A Holistic Approach to Environmental Stewardship: Water Use, Electric Power, and Nuclear Energy

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Topics

- Definitions and Technologies
- Holistic Environmental Management
- EPA Power Plant Cooling System Regulations

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

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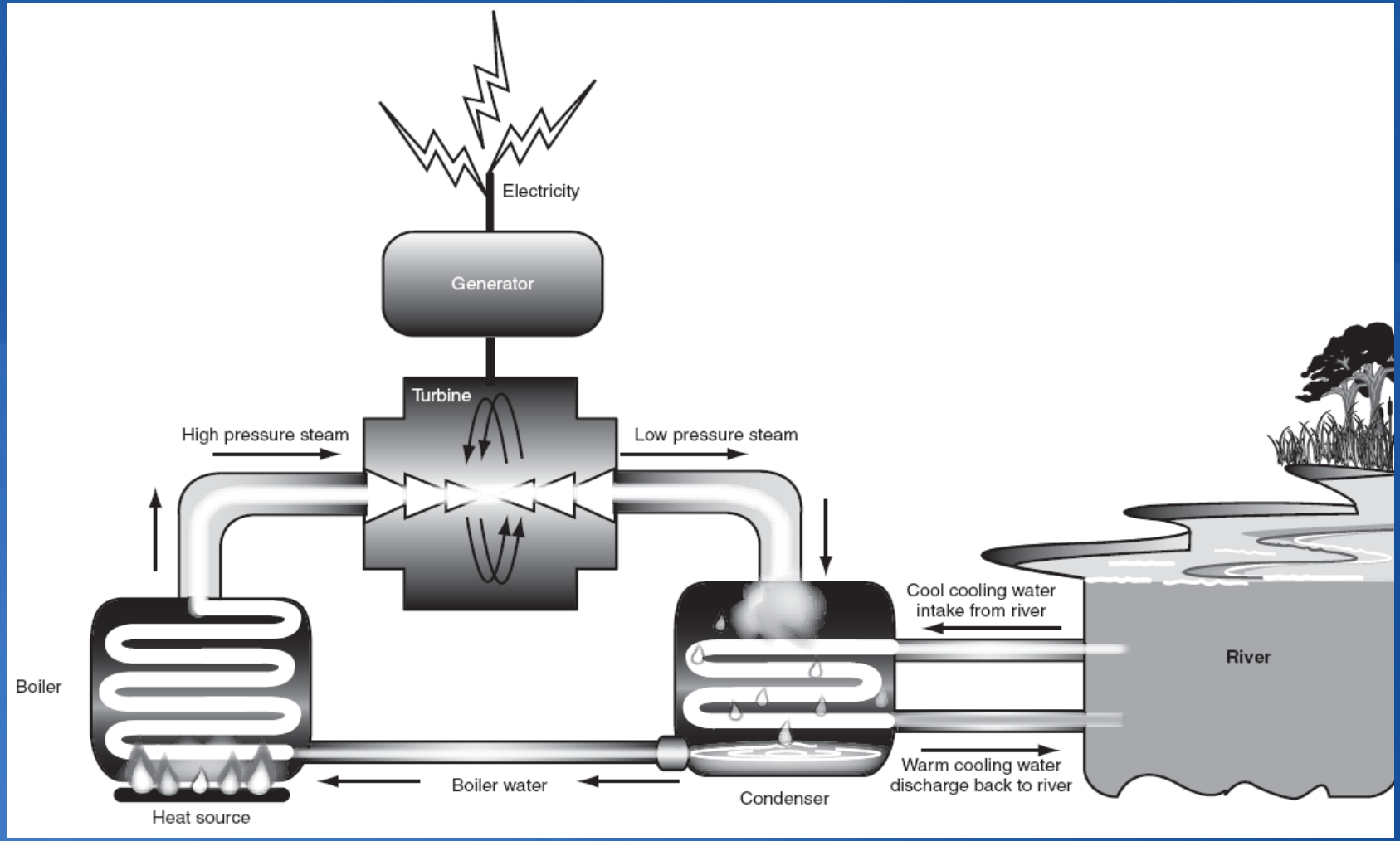
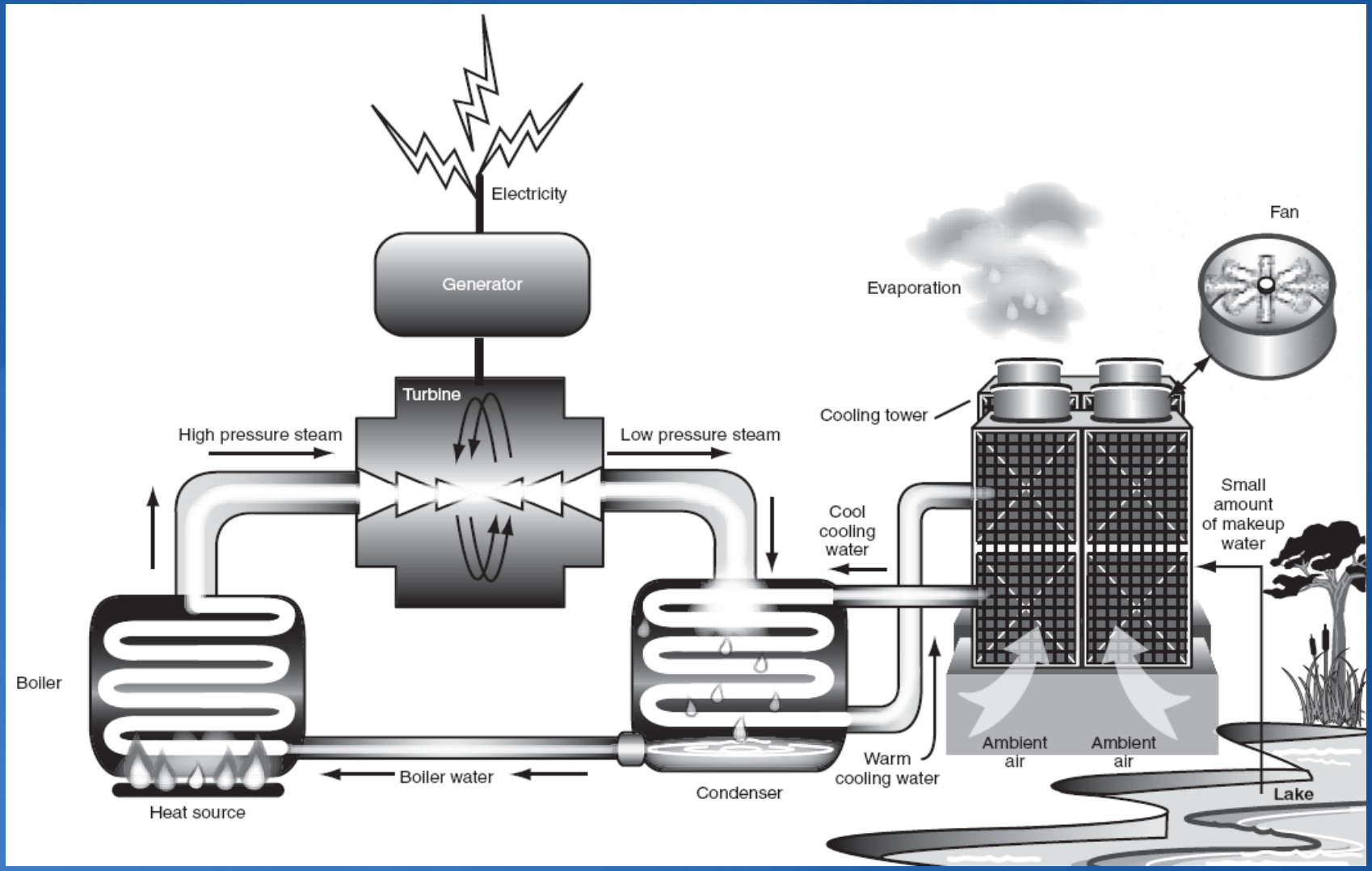
Once-Through Cooling System



Source: U.S. Government Accountability Office

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
- 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

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

Nuclear Power Plant Land Use		
Peach Bottom (2 reactors)	2,200 MW	400 acres
Millstone (2 reactors)	1,900 MW	220 acres
Robinson (1 reactor)	700 MW	240 acres
Pilgrim (1 reactor)	700 MW	140 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; NEI calculation from AWEA data

Air Quality—Emissions

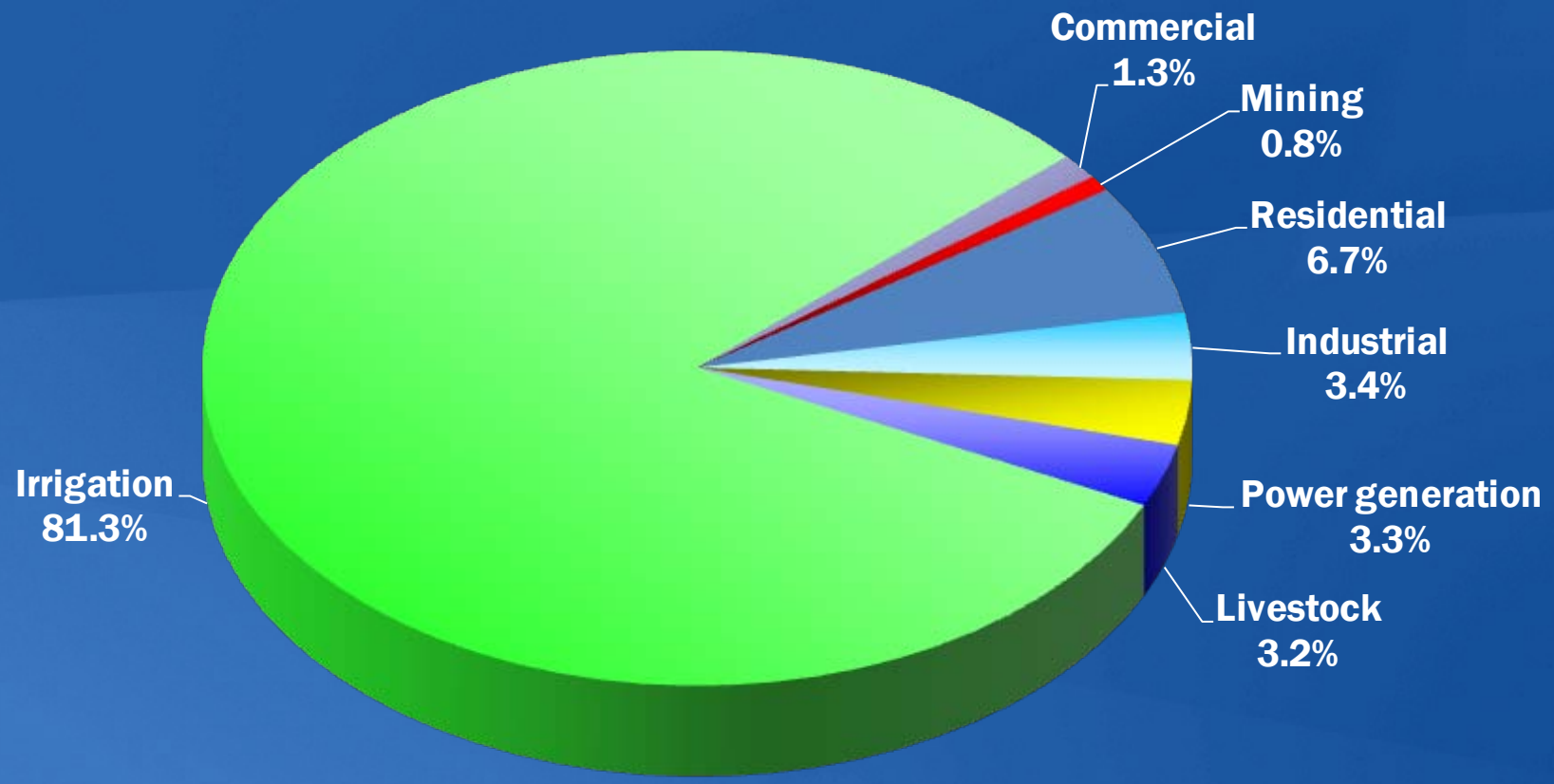
- Nuclear plants during operations produce no NOx (ground level ozone), no SO_2 (acid rain), no CO_2 (climate change)
- Nuclear energy life-cycle CO_2 emissions are comparable to renewables
- Natural gas plants produce half the CO_2 emissions of coal plants

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)

U.S. Water Consumption



Source: US Geological Survey (1995)

Sustainable Development
Environmental Preservation and Economic Progress
(2) Economics

- Standard of living depends upon availability of usable water and electricity
- 90% 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

- Carbon-free energy sources mitigate climate change, alleviate related water shortages
- Nuclear power plants can provide economical electricity and process heat for desalination
- Nuclear power plants can produce large-scale electricity for carbon-free transportation
- Nuclear power plants can use recycled municipal waste water, mine pool water

EPA Power Plant Cooling System Regulations

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EPA Regulations Implementing Clean Water Act Section 316(b)

- CWA Section 316(b) Phase II and Phase III regulations apply to existing power plants and industrial facilities
- 559 power plants affected representing 45% of U.S. electric power sector capacity (EPA)
- Law requires "intake structures reflect the best technology available for minimizing adverse environmental impacts"
- EPA considers fish mortality at the intake structure as adverse environmental impact

Holistic Environmental Management For Cooling System Deployment

(1) Preserve all viable options

Cooling Systems

- Once-Through
- Cooling Towers
- Cooling Ponds
- Hybrid Systems
- Reclaimed Water

Mitigation Technologies

- Physical Barriers
- Collecting Systems
- Diversion Systems
- Behavioral Deterrents
- Restoration

(2) Deploy as appropriate for the specific site in terms of environmental impact and cost-benefit

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Preferred Regulatory Approach

- *Site-specific analysis* to determine the "best technology available" (BTA), considering:
  - Feasibility of installing particular protection technologies
  - Costs and benefits of installing particular protection technologies
  - Potential impacts for all environmental components
- *Range of proven fish protection technologies* eligible for consideration

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Fish Protection Technologies For Once-Through Cooling Systems

- Physical Barriers—Screens
- Collection and Return Systems
- Diversion Systems
- Behavioral Deterrents
- Advanced Technologies:
  - Wedgewire Screens
  - Fine Mesh Screens

Entrainment Requirements
Generally Acceptable—Site-Specific Flexibility

- **State environmental agency determines best technology available for each site according to:**
  - Number/types of organisms entrained
  - Entrainment impacts on waterbody
  - Comparison of "social cost" to "social benefit"
  - Impacts associated with thermal discharge
  - Impacts on energy reliability
  - Emission of pollutants
  - Land availability
  - Remaining plant life
  - Impacts on water consumption

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Impingement Requirements
Unacceptable—One Size Fits All, No Site Flexibility

- One technology is BTA for all sites—traveling screens with collection-return system
- All plants must meet single performance standard—12 percent *mortality* annually
- Only other compliance alternative is reduced water intake velocity—not widely available
- No consideration of *total* impingement reduction already achieved
- Installation of costly, unnecessary, ineffective technologies with no assurance of compliance

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Impingement Mortality Limit Based on Inadequate BTA-Performance Sample Number

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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Impingement Requirements
Necessary Revisions
For Unique Sites, Fish, Waterbodies

- Give states ability to perform site-specific assessments and determine BTA according to a range of factors—feasibility, cost-benefit analysis, potential environmental impact
- Provide compliance flexibility for any national impingement mortality limits or water intake velocity limit, allowing states to take site-specific variability into account
- Give credit for total impingement reduction (both mortality and survival) already achieved

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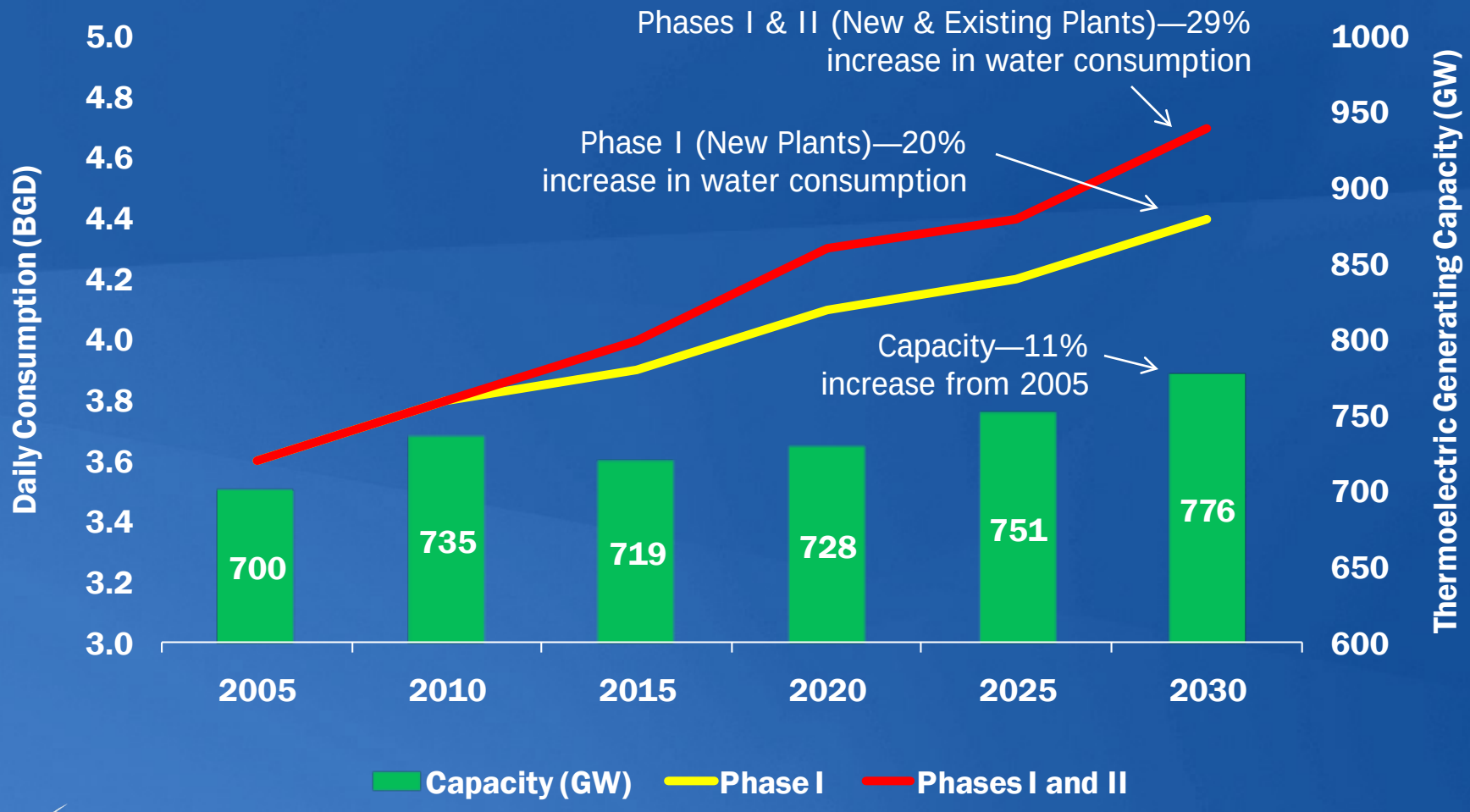
Projected Freshwater Consumption By Thermoelectric Power Generation Under EPA 316(b) Regulations



Source: National Energy Technology Laboratory

Cooling Towers Potential Impacts

- Appropriate for certain ecosystems
- Consume more water
- Use more land
- Produce air emissions—particulate matter and salt drift
- Discharge water containing elevated impurity concentrations
- Less efficient, reducing electricity output, requiring more power plants

United Kingdom Environment Agency: Once-Through Cooling "Best Environmental Option"

- "Hard-and-fast rules . . . are best avoided. Each case should be examined . . . ."
- "[I]creased risk of water shortages . . . could be a further reason to avoid wet tower-cooled freshwater sites."
- ". . . improved understanding of survivability of entrainment process, and substantial developments in impingement techniques."

United Kingdom, Environment Agency, *Cooling Water Options for the New Generation of Nuclear Power Stations in the UK*, June 2010