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

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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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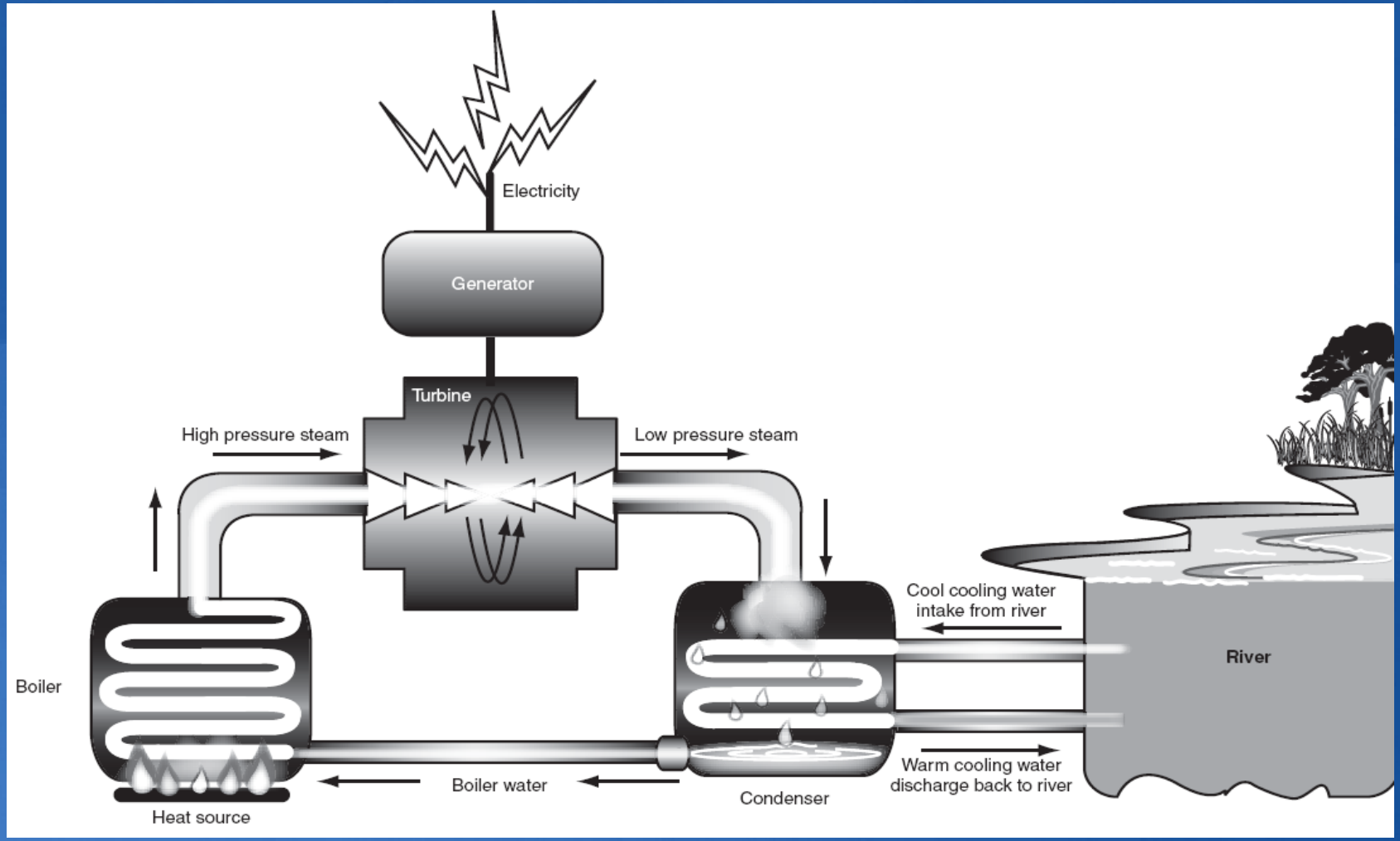
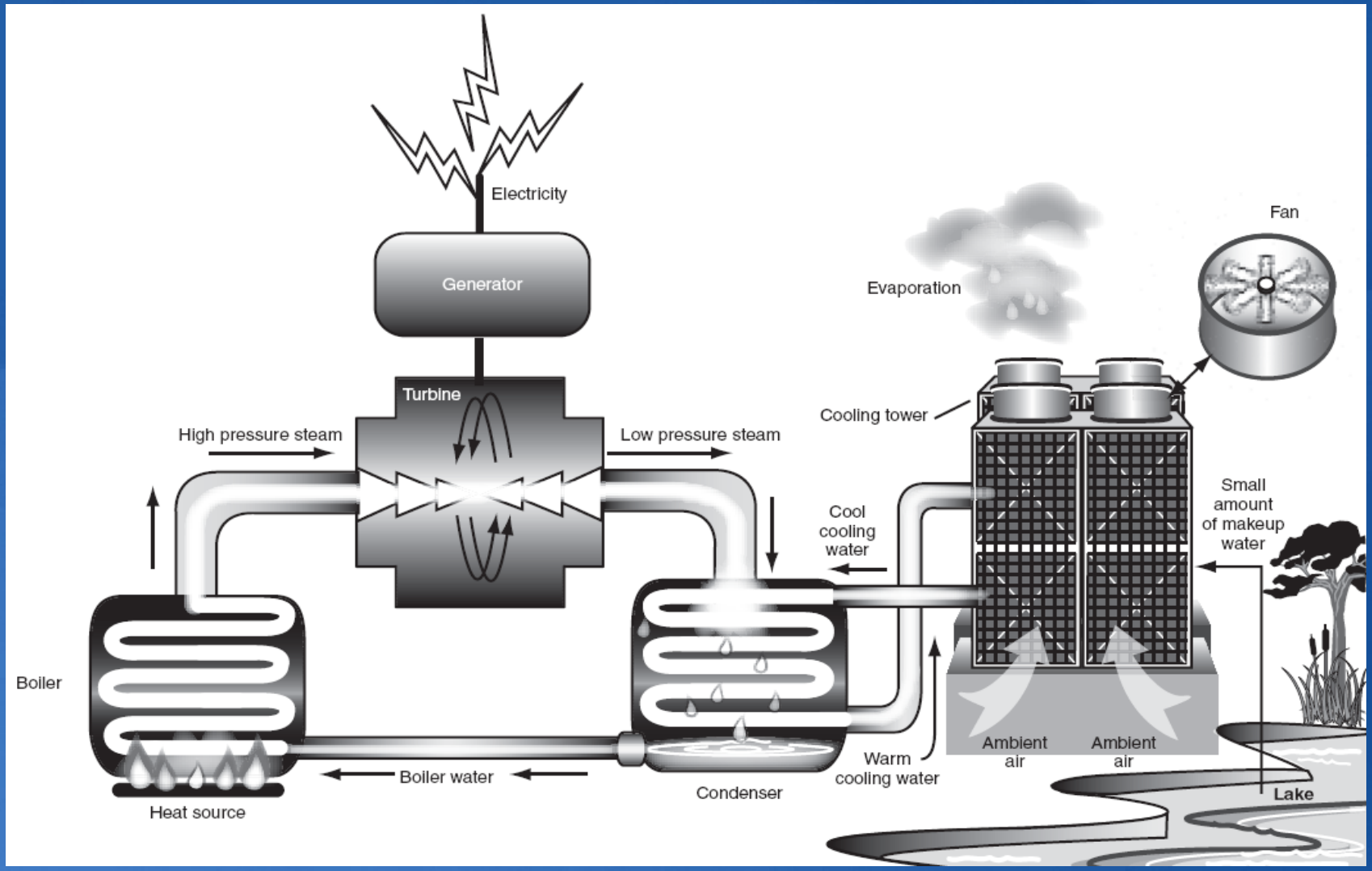
Once-Through Cooling System



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

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, NETL, Peter Gleick

Aquatic Life—Once-Through Systems

- Once-through systems typically impinge .02%-1.4% of species populations in waterbody
- Once-through systems entrain on average .01% to 4% of potential adult fish of species populations in waterbody
- Scientific study demonstrates that once-through systems do not have an adverse impact on aquatic life populations

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Land Use—Habitat (1)

- Nuclear energy requires one-third of 1% of the land required by wind power to produce the same amount of electricity
- T. Boone Pickens' Mesa Power LLP's original wind farm in Texas on 200,000 acres, at the announced capacity factor of 25%, would produce the same amount of electricity as a new advanced nuclear plant on 640 acres at 90% capacity factor

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Land Use—Habitat
(2)

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

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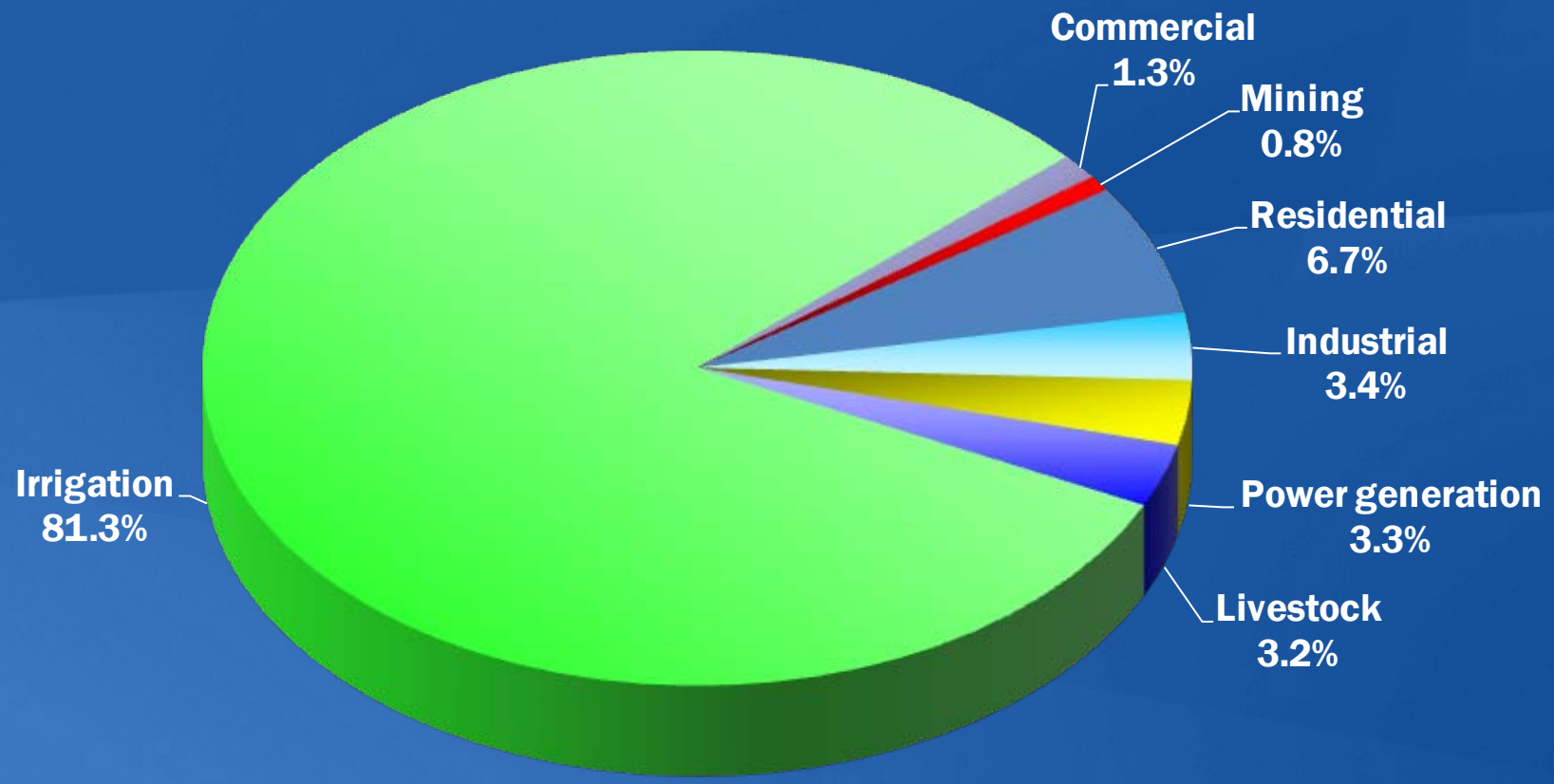
U.S. Water Consumption



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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EPA Power Plant Cooling System Regulations

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EPA Regulations Implementing Clean Water Act Section 316(b)

- CWA Section 316(b) Phase I (new plants) and Phase II (existing plants) regulations, in effect, require cooling towers
- Focus on aquatic life, to their detriment, because of the exclusion of all other environmental considerations
- Establish national standards that do not take into account unique local ecosystem characteristics

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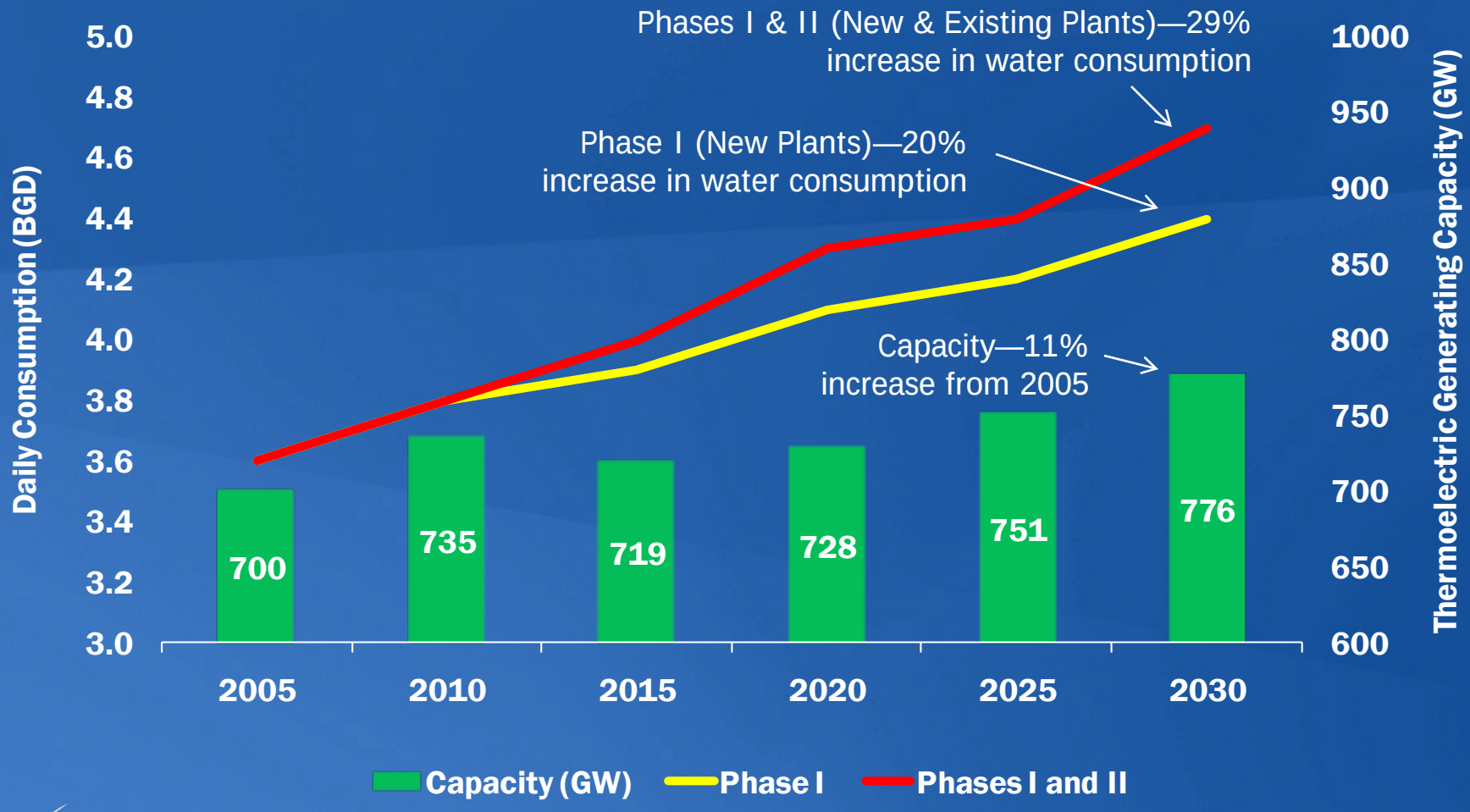
Projected Freshwater Consumption By Thermoelectric Power Generation Under EPA 316(b) Regulations



Source: National Energy Technology Laboratory

Regulatory Reform

- Revised Phase II regulations may require once-through plants to retrofit
- Approach unsupported by scientific evidence
- Cost to consumers—$37 billion to $107 billion for nuclear plants *alone*, just 15% of plants needing retrofits
- Grid reliability jeopardized from less efficient cooling towers and scheduling

Cooling Towers Potential Impacts

- Cooling towers appropriate for certain ecosystems
- Consume more water
- Use more land
- Emit particulate matter, including salt drift
- Discharge water contains elevated impurity concentrations
- Less efficient, reducing electricity output, requiring more power plants

Fish Protection Technologies For Once-Through Cooling Systems

- Physical Barriers
- Collecting Systems
- Diversion Systems
- Behavioral Deterrents
- Advanced Technologies:
  - Wedgewire Screens
  - Fine Mesh Screens

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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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."

Revised 316(b) Regulations
Our Next Steps

- Revised draft Phase II regulations expected to be issued in February
- Public comment period to follow