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

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September 28, 2010
Topics

- Definitions and Technologies
- Holistic Environmental Management
- EPA Power Plant Cooling System Regulations
Definitions and Technologies
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
Holistic Environmental Management
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
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- Once-through systems consume 1% of water withdrawn
- Cooling-tower systems consume 70%-90% of water withdrawn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

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

Sources: EPRI, NETL, Peter Gleick
Aquatic Life—Once-Through Systems

- Once-through systems typically impinge \(0.02\%-1.4\%\) of species populations in waterbody.
- Once-through systems entrain on average \(0.01\%\) 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.
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.
## Land Use—Habitat

### Nuclear Power Plant Land Use

<table>
<thead>
<tr>
<th>Plant</th>
<th>MW</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peach Bottom (2 reactors)</td>
<td>2,200</td>
<td>400</td>
</tr>
<tr>
<td>Millstone (2 reactors)</td>
<td>1,900</td>
<td>220</td>
</tr>
<tr>
<td>Robinson (1 reactor)</td>
<td>700</td>
<td>240</td>
</tr>
<tr>
<td>Pilgrim (1 reactor)</td>
<td>700</td>
<td>140</td>
</tr>
</tbody>
</table>

### Renewables Land Use

<table>
<thead>
<tr>
<th>Source</th>
<th>Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Farm</td>
<td>150,000-180,000 acres</td>
</tr>
<tr>
<td>Solar Park</td>
<td>54,000 acres</td>
</tr>
</tbody>
</table>

Sources: NRC License Renewal EISs; NEI calculation from AWEA data
Air Quality—Emissions

- Nuclear plants during operations produce no NOx (ground level ozone), no SO2 (acid rain), no CO2 (climate change)
- Nuclear energy life-cycle CO2 emissions are comparable to renewables
- Natural gas plants produce half the CO2 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
U.S. Water Consumption

- Irrigation: 81.3%
- Power generation: 3.3%
- Livestock: 3.2%
- Industrial: 3.4%
- Residential: 6.7%
- Mining: 0.8%
- Commercial: 1.3%
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
EPA Power Plant Cooling System Regulations
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**
Projected Freshwater Consumption By Thermoelectric Power Generation Under EPA 316(b) Regulations

- Phase I (New Plants)—20% increase in water consumption
- Phases I & II (New & Existing Plants)—29% increase in water consumption
- Capacity—11% increase from 2005

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
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