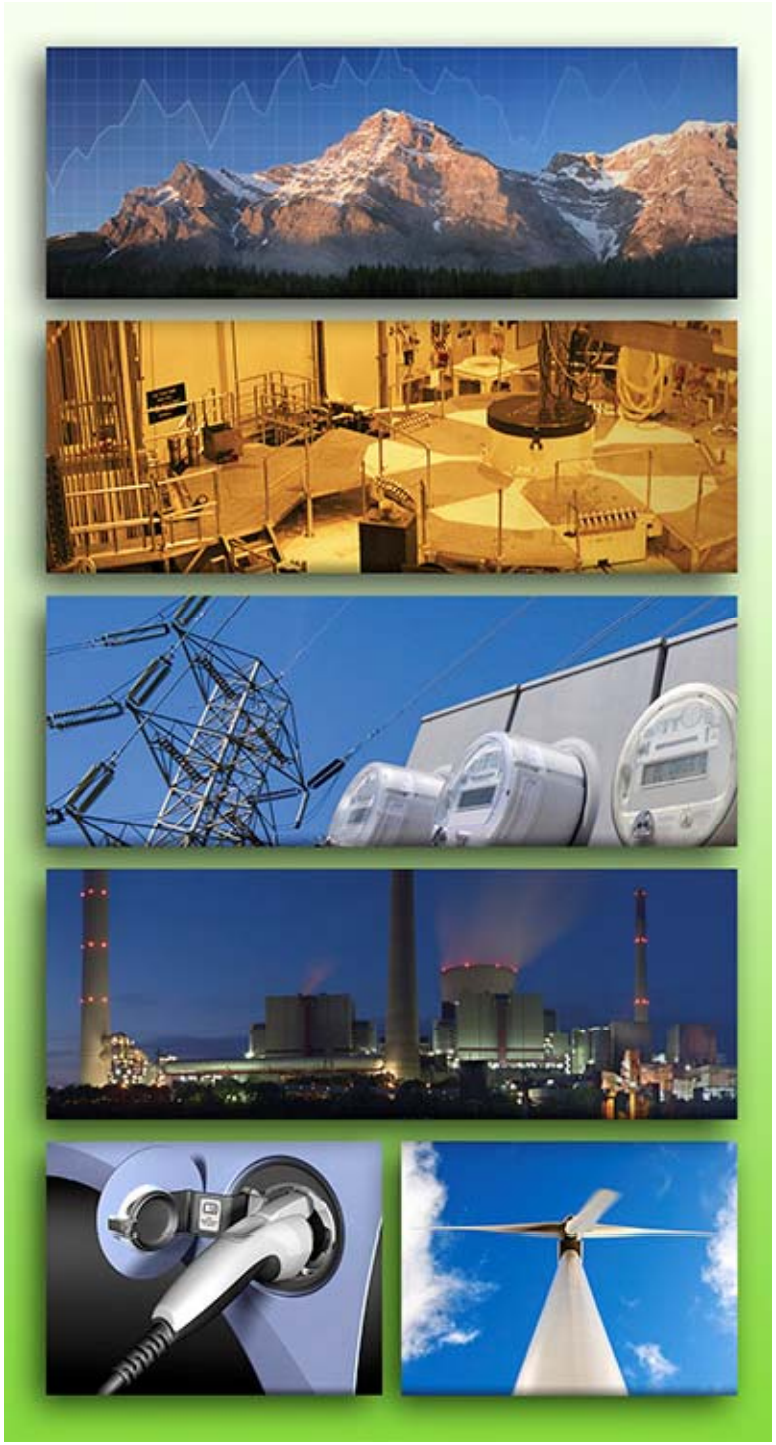

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EPRI and INL Collaborative R&D on Nuclear Power Plant Cooling Water Issues

Life Beyond 60 Workshop
Washington DC
24 February 2011

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Why Cooling Water is Important to Life Beyond 60

- Water is a critical resource; competition growing among diverse users for non-expandable fresh water resources
- All life extension decisions ultimately business decisions
- Potential for cooling tower retrofitting as a “showstopper”
  - Recent EPRI study: >$95B to US industry (NPPs: >$32B)
  - Potential for increasing fees for access to cooling water
- Future water conflicts could jeopardize security of supply
- “The seriousness of the water crisis will impinge on our lives much earlier than climate change” (WEF)
  - Cost impacts of CT retrofitting > pending individual CAA regs
- Water issues are major part of NRC’s Env. Review (P. 51)
- Even greater impacts on new plants
  - “Water is the pivotal issue for new plant siting”

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Programmatic Context for Cooling Water Issues

- Water use conflicts are largely policy-driven
  - "…role of federal policies in contributing to rising water demand…" (Nov. 2010 CRS Report)
  - One key policy driver: EPA's Clean Water Act (CWA; § 316(b).)
- Energy-Water "Nexus" based on mutual dependency
- Multiple industry orgs. engaged (NEI, EEI, EPRI, UWAG)
- 20+ federal agencies share responsibility for water policy
- Many Offices within DOE (NE, FE, OE); same at EPRI
- No simple generic solutions for NPPs: All sites & regions are impacted, but most solutions are largely site-specific
  - More broadly, "no silver bullets" (e.g., alternative energy sources)
- R&D can play an important role, but funding for nuclear-focused cooling water R&D is modest and tentative

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OTC vs. CCC: Pros and Cons

- OTC vs. CCC decision made at design phase. Very difficult and costly to retrofit CCC after construction of OTC nuclear plant.
  - Site layout considerations; larger footprint required for cooling towers or cooling ponds
  - Intake & discharge structures plus entire BOP optimized to cooling system design (condenser; condensate & circ water piping/pumps, etc.)
- Pressure on thermoelectric plants to use less fresh water is in direct conflict with pressure to shift from OTC to CCC
- OTC advantages: most reliable & least costly alternative; lowest water consumption rate; no particulate/CAA ("drift") issues; no habitat loss, noise or aesthetic issues; no production penalties.
- CCC advantages: less likely to cause environmental impact on aquatic life (some sites). Impacts site-specific & species-specific; typically only at intake structure. Needed on small river sites.

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Dec. 2009 EPRI Executive Survey: Interview Demographics

75 interviews with 89 executives

- Balanced, high-level representation
- >65% vice presidents or higher

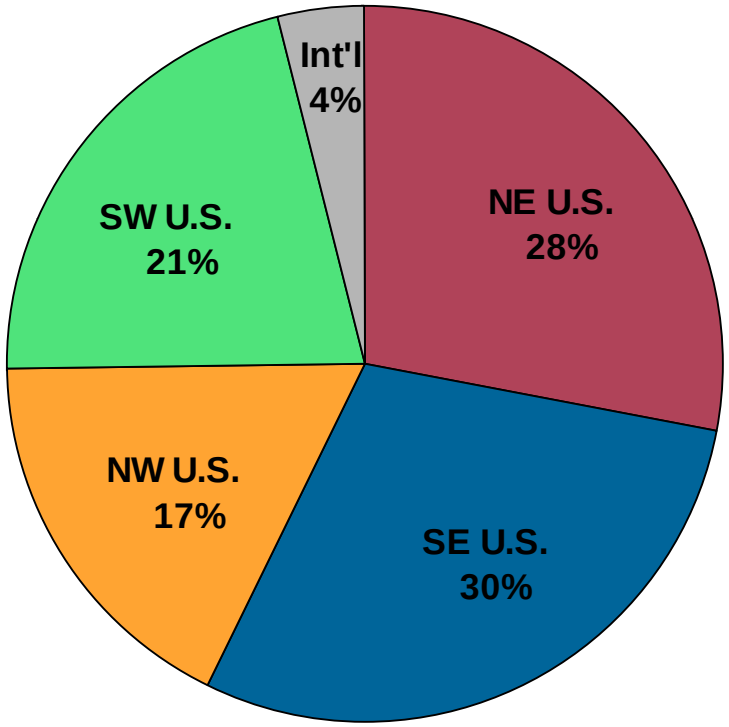
EPRI involvement

- 68% are EPRI advisors; 32% are not
- 26 EPRI Council Members
  - 7 Nuclear Power Council representatives
  - 9 EPRI Generation Council representatives
  - 9 EPRI Environment Council representatives
- 8 Advanced Nuclear Technology Advisors
- 6 EPRI Board & RAC Members

Nuclear Status

- 35% Nuclear, 32% Fossil, 33% Environment
- 81% from companies with nuclear plants
- 51% from companies with COL applications
- 49% with closed cycle cooling at existing nuclear
- 60% with once through cooling at existing nuclear

Regional Demographics



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EPRI Executive Survey: Conclusions

- Water issues are a concern to all utility executives. Even those companies with abundant water supplies are concerned about future regulations and competition for resources
  - Greatest concern for new nuclear plants
- Many water issues challenge utilities. A majority rated 4 areas "extremely" or "very important" for EPRI R&D
  - Concerns vary depending on plant location and type
- Challenges are expected to grow in 3-5 years due to stricter regulations and increased public attention to water scarcity
  - Impacts translate into higher costs
- There is a clear mandate for an active EPRI R&D role to provide practical, economical, and timely solutions
  - Widespread interest in devoting time to working with EPRI

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14 April 2010 EPRI-INL Strategy Meeting in Charlotte NC
Objective: Identify Issues and Solution Paths to Minimize the Consumptive Use of Water by NPPs

- Identify & prioritize top plant cooling issues that impact:
  - Volume of NPP water usage
  - New plant siting, design and licensing
  - Continued safe & economic operation of the current fleet
- Address long-term water availability; water use conflicts:
  - Anticipate potential policy or legislative actions
  - Anticipate future industry initiatives and needs
- Identify issue solutions; include "out of the box" ideas:
  - Include actions in all areas – technology, operational processes, environmental data collection, collaborative initiatives with other stakeholders, benchmarking activities, policy initiatives, etc.
- Basis for collaborative R&D actions by EPRI/DOE/INL
  - Benefit both new & operating plants; Generic to many/most sites

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Obtaining and Ranking Utility Recommended Actions to Address Cooling Water Issues

- 20 utility participants at EPRI/INL April 14th meeting
  - Open Forum Discussion – numerous ideas and recommendations
  - Compiled total of 49 potential action items from open forum
- Prioritization process
  - 49 action items transmitted to Technical Advisory Group (TAG) for prioritization (H, M, L rankings; scored by 14 advisors)
  - Rankings plus consolidations resulted in 8 proposed R&D projects
- Strong industry support for EPRI/DOE/INL collaboration
  - Industry supports DOE's role as government's advocate for energy security and reliability
  - DOE engagement could help restore balance to water use issues

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Eight Proposed Project Descriptions

1. Identify innovative strategies for reducing consumptive use of water #
2. Peer-reviewed technical paper on tradeoffs between OTC vs. CCC #

   (water consumption implications, fish protection measures, etc.)
3. Template for exemption of req'ts to implement CCC on new plants #
4. Wet cooling tower performance R&D (particulate/salt drift; reduced water consumption; O&M issues)
5. Dry cooling tower R&D (new plant issue only; safety/reliability issues)
6. Support DOE-NE / DOE-FE / DOE-OE effort to create an Action Plan on cooling water issues impacting U.S. energy security
7. Methodology for holistic (also generally applicable yet flexible) Environmental Impact Assessment of energy/water issues #
8. Field demonstrations of screen technologies (wedge-wire; fine mesh)

= highest priority

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NPP Cooling Water Report to DOE, Dec. 2010

- Global overview of water as strategic issue (global & national)
- Background (withdrawal vs. consumption, OTC vs. CCC (including technologies); intake structure technologies; comparative water consumption rates
- Federal Regulations; roles of EPA (CWA) and NRC (NEPA)
- Categorizing U.S. NPPs based on cooling water systems
- EPRI studies on CWA 316(b) rule impacts
- Interviews with NPP cooling water experts
- What next after 2009 Supreme Court decision
- Planning assumptions and strategic priorities
- Recommendations

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Cooling Water Withdrawal & Consumption (Evaporation to Atmosphere) Rates for Common Thermal Power Plant and Cooling System Types (EPRI, 2003)

Plant and Cooling System Type	Water Withdrawal (gal/MWh	Typical Water Consumption (gal/MWh)
Fossil/biomass/waste-fueled steam, once-through cooling	20,000 to 50,000	~300
Fossil/biomass/waste-fueled steam, pond cooling	300 to 600	300-480
Fossil/biomass/waste-fueled steam, cooling towers	500 to 600	~480
Nuclear steam, once-through cooling	25,000 to 60,000	**~400**
Nuclear steam, pond cooling	500 to 1100	**400-720**
Nuclear steam, cooling towers	800 to 1100	**~720**
Natural gas/oil combined-cycle, once-through cooling	7500 to 20,000	~100
Natural gas/oil combined-cycle, cooling towers	~230	~180
Natural gas/oil combined-cycle, dry cooling	~0	~0
Coal/petroleum resid.–fueled combined-cycle, cooling towers	~380*	~200

Nuclear Plant Sites (by Cooling Water "Situation")

Situation number	Situation Description	Number of Sites	Number of Reactors
1A	Site uses wet closed cycle cooling towers at all reactor units on that site (natural draft, mechanical or combination)	22	32 (+2)#
1B	Site uses once-through cooling on a man-made cooling pond (or canal system) that has been judged to not be a "waters of the U.S." and thus exempt from EPA's CWA § 316(b) requirements. These sites are treated under the CWA as functionally equivalent to closed-cycle cooling tower plants (Situation 1A above)	4	8
2	Site uses once-through cooling on a man-made cooling pond that has been judged to be "waters of the U.S." and thus not exempt from EPA's CWA § 316(b) requirements.	7	10
3	Site uses once-through cooling on a multi-purpose reservoir (in-line with source river)	7	15 (-1)#
4	Site uses once-through cooling on an ocean, or bay that is open to the ocean (i.e., with ocean salinity levels)	7	11
5	Site uses once-through cooling on an estuary or tidal river	6	11
6	Site uses once-through cooling on a freshwater river (free flowing)	6	8
7	Site uses once-through cooling on a Great Lake	6	9 (-1)#
TOTALS	(# Two sites with both a closed-cycle cooled unit and a once-through cooled unit are listed under the applicable once-through category.)	**65**	**104**

Implications for New Plants (from Dec. 2010 Report to DOE)

- Climate change models and credible policy responses to reducing fossil fuel emissions all require major reliance on nuclear, renewables
- Nuclear will be relied upon increasingly for new missions (power for plug-in hybrids, desalination, process heat for petrochemical industry)
- Major expansion of nuclear will require use of both existing & new sites. Availability of existing sites is limited ⟶ many new sites
  - CWA Phase I Rule effectively requires CCC for all new plants: problematic
  - Imposing CCC on existing units may preclude new units at same site
- Areas of U.S. with greatest water resource challenges are often areas of highest projected population growth ⟶ water use conflicts
- OTC option (with IM&E protections) needs to be preserved
  - In regions with water consumption issues (e.g., upper Great Lakes, South)
  - In regions where CCC technology is problematic (e.g., ocean sites)
- Other creative options needed (cooling ponds, alternative sources, etc.)

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"Below the Line" R&D Needs

- Expanded use of cooling ponds and pumped storage
- Drought mitigation & reservoir preservation/expansion
- Non-traditional cooling water options, including:
  - Saline aquifers and collector wells (undrinkable groundwater)
  - Reclaimed or reprocessed water (municipal water treatment facilities)
  - "Produced" water from energy production (oil and gas wells and mine pool water in abandoned coal mines)
  - excess run-off from irrigation
- Collaboration with other water-use stakeholders
- Collaboration between electric utilities and water utilities
- Cost-effective uses of waste heat

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