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

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September 15, 2009

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Assumption: Energy Diversity

- In addition to efficiency and conservation measures, all available energy sources will be required to meet projected future electricity demand, energy security, and environmental goals, as their respective advantages and limitations complement each other. As time goes on, there will be a transition to cleaner energy sources.

Conclusion:
Holistic Environmental Stewardship

- Holistic environmental management requires balancing the relationships among all relevant issues and making responsible trade-offs appropriate to the unique characteristics of each ecosystem where an electricity generating facility exists or is to be deployed. This comprehensive, integrated approach will yield an optimal result for all issues, including water use.

Topics

- Local Ecosystem Considerations
- Broader Environmental Issues
- Future Directions

Local Ecosystem Considerations

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Water Quantity

- Once-through systems consume 1% of water withdrawn
- Cooling-tower systems consume 70%-90 % of water withdrawn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

Water Quality

- Cooling system discharge water temperatures and impurities conform to EPA or state regulations
- Once-through system thermal pollution is mitigated by cooling canals or after-bays before discharge to the main water body

Aquatic Life

- Once-through systems impinge on average 1%-2% 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 cooling water systems do not have an adverse impact on aquatic life populations

Wildlife

- Wind power and nuclear energy have the lowest potential life-cycle impact on wildlife of all energy sources
- Life-cycle: fuel extraction and transportation, facility construction, power generation, transmission, decommissioning
- Impacts: physical or chemical injury and mortality, behavior disruption, habitat destruction or alteration

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
(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

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

Broader Environmental Issues

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Climate Change Mitigation

- Currently 74% of U.S. emission-free electricity is produced by nuclear energy
- Nuclear plants generate electricity on average 90% of the year, renewables 30% Renewables' intermittent, variable output must be backed-up by rapid-start sources, typically natural gas plants
- All credible carbon-reduction proposals call for expansion of nuclear energy

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Climate Change Adaptation

- Energy sources producing no greenhouse gases, by mitigating climate change, can alleviate related water shortages
- Nuclear power plants can provide economical electricity and process heat for desalination
- Nuclear power plants can produce reliable large-scale electricity required by a carbon-free transportation sector

Sustainable Development
Environmental Preservation and Economic Progress (1)

- 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

Sustainable Development
Environmental Preservation and Economic Progress (2)

- Thermoelectric power plants return 98% of the water they withdraw
- 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

U.S. EIA Projected Levelized Cost of New Generation, 2016

Plant Type	Capacity Factor (%)	U.S. Average Levelized Costs (2007 $/Megawatt-hour) for Plants Entering Service in 2016				
		Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85	64.5	3.7	23.0	3.5	94.6
Advanced Coal with CCS	85	87.4	6.2	25.2	3.8	122.6
Natural Gas-fired						
Conventional Combined Cycle	87	23.0	1.6	55.7	3.7	83.9
Advanced CC with CCS	87	43.6	2.6	65.8	3.7	115.7
Advanced Nuclear	**90**	**84.2**	**11.4**	**8.7**	**3.0**	**107.3**
Wind	35.1	122.7	10.3	0.0	8.5	141.5
Wind – Offshore	33.4	193.6	27.5	0.0	8.6	229.6
Solar PV	21.7	376.6	6.2	0.0	12.9	395.7
Solar Thermal	31.2	232.1	21.3	0.0	10.3	263.7
Geothermal	90	86.0	20.7	0.0	4.8	111.5
Biomass	83	71.7	8.9	23.0	3.9	107.4
Hydro	52	97.2	3.3	6.1	5.6	114.1

Source: Energy Information Administration, Annual Energy Outlook, April 2009 SR-OIAF/2009-03

Future Directions

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Regulatory Reform

- Clean Water Act Section 316(b) Phase I (new plants) and Phase II (existing plants) regulations
- 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

Research and Development in Progress

- R&D conducted by EPRI, often in partnership with DOE national laboratories
- *Once-through*—technologies to minimize impingement and entrainment
- *Recirculating*—reduce water consumption; recycle degraded water
- *Dry cooling*—improve air-cooled condenser
- *Hybrid cooling*—operating performance optimization

Nuclear Energy in a Water Constrained Environment (1)

- *Why?*—Large-scale economical electricity and process heat for desalination
- *How?*—Reclaimed degraded water
- *Example*—Palo Verde Nuclear Generating Station, located in the Arizona desert, has used recycled municipal wastewater since beginning operations in 1985—the largest U.S. electric generating facility of any kind

Nuclear Energy in a Water Constrained Environment (2)

- *How?*—ocean water
- *Example*—Diablo Canyon Power Plant, Avila Beach, San Luis Obispo County, California, 2,240 MW capacity
- *Example*—San Onofre Nuclear Generating Station, San Onofre State Beach, San Diego County, California, 2,254 MW capacity

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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http://www.nei.org/resourcesandstats/documentlibrary/protectingtheenvironment/whitepaper/water-use-electric-power-and-nuclear-energy

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