Energy-Water Nexus

Fall Semester 2011

Instructors

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Course summary

New insights on the coupled resource linkages between water and energy have moved water-energy nexus analysis beyond straightforward quantification of energy-for-water and water-for-energy. In the context of global change (including climate change, rapid urbanization, and global markets for energy, biofuels, and food), research and decision-making on these coupled resources increasingly focuses on:

- spatial patterns of water and energy use (source to consumption),
- mutual influences between energy and water policy and planning
- internalizing 'externalities' (unintended consequences—indeed reinterpretation—of 'waste, including deferred impacts), and
- policy formulation (with emphasis on global change adaptation involving water and energy that does not undermine long-term mitigation)

The seminar will address the following list of topics:

- the energy futures to meet urban and agricultural water demand,
- water resources needs for power generation using conventional fuels and renewables,
- the implications and role of water in the emerging carbon economy,
- comparative energy- and water-based perspectives on efficiency and conservation, and
- the co-evolution of research and policy-making on water and energy that lead to enhanced societal outcomes.

Course materials

Reading materials will be distributed using D2L.

Grading policy

Grades are based on regular participation in seminar discussions, and satisfactory completion of a term paper developed as a publishable manuscript that is conceptualized, researched, orally presented in class (with feedback from the instructor and fellow students), and finalized as part of the course. Papers that the instructors deem to be publishable will be considered for a special issue of the journal (TBD).

Requirements

No course pre-requisites.

SCHEDULE of TOPICS (subject to revision as agreed/ announced)

Date	Topic	Reading *see prelim biblio on next page
Wk 1	Coupled resources, decoupled policy	TBD
Wk 2	The conventional energy-water nexus	
Wk 3	I. Water for energy: a) Fossil-fuel based with climate implications	
Wk 4	b) Hydropower – Chile and relevant cases	
Wk 5	c) Renewables and the energy-water nexus	
Wk 6	d) Energy resource extraction – environmental and social costs	
Wk 7	II. Energy for water: a) Urban water supply, augmentation, wastewater	
Wk 8	b) The groundwater irrigation – electrical power nexus	
Wk 9	c) Desalination	
Wk 10	d) 'Waste' remediation, resource recovery	
Wk 11	Efficiency and conservation – energy and water analogs, differences, and synergies	
Wk 12	Small-scale, 'appropriate tech' solutions	
Wk 13	Energy and water for global change adaptation and mitigation	
Wk 14	*Research paper presentations, discussion, feedback*	
Wk 15	*Paper presentations … continued*	
Wk 16	The future	

Final note

All information contained in this syllabus (other than the grading policy portion) may be subject to change with reasonable advance notice.

Bibliography

Arizona Corporation Commission (ACC). 2002. *Toltec Power Project Denied.* http://www.azcc.gov/divisions/utilities/news/pr01-31-02.htm Accessed Feb. 23, 2010.

Baber, B. H. 1988. "Grandpa, all you bought was the air!" Caligraphic Print Tending the Commons: Folklife and Landscape in Southern West Virginia. American Folklife Center. Washington, DC: Library of Congress.

Banks, A., A. Jones, and A. Blakeney. 2005. Headwaters: A student/faculty participatory research project in an eastern Kentucky community. *Journal of the Appalachian Studies Association* 11(1/2): 104-132.

Bauer, C.J. 20XX. Dams and Markets: Rivers and Electric Power in Chile. *Natural Resources Journal.*

Brownell, M. 2008. Gas well drilling and development: Marcellus shale. *Susquehanna River Basin Commission*. http://www.srbc.net/whatsnew/docs/Marcellusshale61208ppt.PDF. Accessed Jan. 30, 2010.

Bureau of Reclamation. 2003. Desalination and Water Purification Technology Roadmap, a Report of the Executive Committee, Sandia National Laboratories and the U.S. Bureau of Reclamation, 83 p.

California Energy Commission (CEC), 2005. Integrated energy policy report. http://www.energy.ca.gov/2005publications/CEC-100-2005-007/CEC-100-2005-007-CMF.PDF.

Central Arizona Project (CAP), 2007/2008. Final 2007/2008 rate schedule. http://www.cap-az.com/static/index.cfm?contentID=30.

City of Tucson and Pima County. 2009. Water and Wastewater Infrastructure, Supply, and Planning Study Phase II Final Report.

City of Tucson Water Department. 2004. Water Plan: 2000-2050.

City of Tucson Water Department. 2008. Update to Water Plan: 2000-2050.

Cohen, R., Nelson, B. & Wolff, G. 2004. Energy Down the Drain, the Hidden Costs of California's Water Supply. NRDC and Pacific Institute.

Collins, Karen. 2009. Salt River Project - A Water/Power Nexus for over 100 Years. Southwest Renewable Energy Conference: Integrating Policy with Technology to Bring Renewables to the Grid, Flagstaff, Arizona, September 11, 2009.

Comisión Federal de Electricidad (CFE), 2006. Unpublished energy sales data.

Cooley, Heather, 2007. Energy implications of alternative water futures. Presented at First Western Forum on Energy & Water Sustainability, Bren School of Environmental Science & Management, University of California, Santa Barbara, March 22-23, 2007.

Copeland, C. 2005. "Wastewater treatment: Overview and background." *Congressional Research Service.*

Department of Energy (DOE), 2005. Diminishing water resources and expanding energy demands: the energy water nexus in the United States, Draft Report to Congress, November 18, 2005.

Department of Energy (DOE). 2006. *Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water*. Department of Energy. 80 pp.

Department of Energy (DOE). 2007. *Clean Coal Technology: Power Plant Optimization Demonstration Projects*. Topical Paper Number 25. http://www.netl.doe.gov/technologies/coalpower/cctc/topicalreports/pdfs/topical25.pdf

Electric Power Research Institute (EPRI). 2002. *U.S. Water Consumption for Power Production; and U.S. Electricity Consumption for Water Supply & Treatment*. Palo Alto: EPRI.

Eller, R. D. 2009. *Uneven Ground: Appalachia Since 1945*. Lexington: University of Kentucky Press.

Energy Information Administration (EIA).2008. *Annual Energy Outlook 2008 with Projections to 2030*. Report DOE/EIA-0383 (2008). http://www.eia.doe.gov/oiaf/archive/aeo08/pdf/0383%282008%29.pdf

Energy Information Administration (EIA). 2010. *Coal Independent Statistics and Analysis*. http://www.eia.doe.gov/fuelcoal.html. Accessed Feb. 2, 2010.

Franco, Guido, Robert Wilkinson, Alan H. Sanstad, Mark Wilson, Edward Vine, 2003. *PIEREA Climate Change, Research, Development, and Demonstration Plan,* California Energy Commission.

Government Accountability Office (GAO). 2009. Energy-Water Nexus. Improvements to Federal Water Use Data Would Increase Understanding of Trends in Power Plant Water Use. GAO-10-23. October 2009. Washington, DC: United States Government Accountability Office.

Griffiths-Sattenspiel, B., and W. Wilson. 2009. *The Carbon Footprint of Water*. Portland: River Network.

Guhathakurta, S., and P. Gober. 2007. The impact of the Phoenix urban heat island on residential water use. *Journal of the American Planning Association* 73(3): 317-329.

Hightower, M., and S. A. Pierce. 2008. The energy challenge. *Nature* 452(20): 285-286.

Hightower, Mike, 2007. At the crossroads: energy demands for water versus water availability. *Southwest Hydrology*, May/June 2007: 24-25, 37.

Holzinger, K., and C. Knill. 2004. Competition and cooperation in environmental policy: individual and interaction effects. *Journal of Public Policy* 24(1): 25-47.

Hoover, J.H., and C.A. Scott. In review. Electrical energy for urban water and wastewater service provision in Arizona. *Journal of Environmental Management.*

Intergovernmental Panel on Climate Change (IPCC). 2007. *Fourth Assessment Report*. Cambridge: Cambridge University Press.

Jacobs, John, Thomas A. Kerestes, and Rick Riddle. 2002 draft. Best practices for energy management. Awwa Research Foundation, Denver, Colorado.

Jentgen, Larry, Harold Kidder, Robert Hill, and Steve Conrad. 2007. Energy management strategies use short-term water consumption forecasting to minimize cost of pumping operations. *Journal of the American Water Works Association* 99(6): 86-94.

Jerrett, M., S. J. Rey, C. Dufournaud, and D. Jones. 2003. Accounting for the environmental "bottom line" along the U.S.-Mexico border. *Annals of the Association of American Geographers* 93(1): 67-88.

Jones, A., E. Smith, and J. Combs. 2007. The "big dip": A diagnostic field analysis of water quality in eastern Kentucky. Eastern Kentucky Environmental Research Institute Report RS07.001.

Kenway, Steven, Carol Howe, and Shiroma Maheepala. 2007. Triple Bottom Line Reporting of Sustainable Water Utility Performance. Awwa Research Foundation, Denver, Colorado, and Commonwealth Scientific and Industrial Research Organisation.

LaChappelle, P. R., S. F. McCool, and M. E. Patterson. 2003. Barriers to effective natural resource planning in a "messy" world. *Society and Natural Resources* 16: 473-490.

Leichenko, R. M., and O'Brien, K. L. 2008. *Environmental Change and Globalization: Double Exposures*. Oxford: Oxford University Press.

Lofman, Denise, Matt Petersen, and Aimée Bower. 2002. Water, Energy and Environment Nexus: The California Experience. *International Journal of Water Resources Development.* 18 (1): 73-85. DOI: 10.1080/07900620220121666

Means, Edward G. III, Lorena Ospina, Nicole West, and Roger Patrick. 2004. A Strategic Assessment of the Future of Water Utilities. Awwa Research Foundation, Denver, Colorado.

Mehan, G. Tracy. 2007. Energy Management: The Fifth Pillar of Sustainable Infrastructure? *Water Environment & Technology* August 2007, Vol. 19, No. 8 (http://www.wef.org/ScienceTechnologyResources/Publications/WET/07Aug/viewpointAugust07.htm).

Montz, B. E., K. Wilmer, S. Walsh-Haehle, N. Lazarus, Y. Kucuker, M. Herr, and N. Greenler. 2010. Interconnections in resource development: controversies surrounding the Marcellus shale in New York. *The Northeastern Geographer*, September, forthcoming.

National Energy Technology Laboratory (NETL), 2006. Estimating freshwater needs to meet future thermoelectric generation requirements. DOE/NETL-2006/1235, August 2006.

Norman, E. S., and K. Bakker. 2009. Transgressing scales: water governance across the Canada-U.S. borderland. *Annals of the Association of American Geographers* 99(1): 99-117.

Palmer, M. A., E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, E. Foufoula-Georgiou, M. S. Hendryx, A. D. Lemly, G. E. Likens, O. L. Loucks, M. E. Power, P. S. White, and P. R. Wilcock. 2010. Science and regulation: Mountaintop mining consequences. *Science* 327: 148-149.

Pasqualetti, M. 2003. Saving the West from the Landscapes of Power. In Patricia Nelson Limerick, Andrew Hildner, Claudia Puska, Eric Skovsted. *What Every Westerner Should Know about Energy*. Report from the Center #4. Center of the American West. University of Colorado, Boulder, p. 16

Pasqualetti, M. 2007. Energy Landscapes of the Southwest: The Costs of Sprawl, 91st Arizona Town Hall: *Land Use: Challenges and Choices for the 21st Century*, Phoenix.

Pasqualetti, M. 2007. The Effect of the Water/Energy Nexus in Arizona on Public Policy, paper prepared for the Arizona Water Institute.

Pasqualetti, M., and S. Kelley. 2007. *The Water Costs of Electricity in Arizona*. Tucson: Arizona Water Institute.

Pitzer, Gary. 2009. The Water-Energy Nexus in the Colorado River Basin. Colorado River Project, River Report, Summer 2009. Sacramento: Water Education Foundation.

Rayburn, Chris, Rich Kottenstette and Mike Hightower, 2007. Advanced water treatment impacts on advanced water treatment impacts on energy-water linkages. Presented at First Western Forum on Energy and Water Sustainability, Santa Barbara, March 2007.

Sandia National Laboratories (SNL). 2005. *Regional Meeting National Synopsis, The Energy-Water Nexus*. http://www.sandia.gov/energy-water/ Accessed Oct. 1, 2009.

Sandia National Laboratories (SNL). 2010. *Energy-Water Challenges and Research and Development Issues*. Report prepared for Department of Energy review and released by Sandia National Laboratories, 100pp.

Scott, C.A., M.J. Pasqualetti. Accepted. Energy and water resources scarcity: Critical infrastructure for growth and economic development in Arizona and Sonora. *Natural Resources Journal*, 50.1: XX.

Scott, C. A., R. G. Varady, A. Browning-Aiken, and T. W. Sprouse. 2007. Linking water and energy along the Arizona/Sonora border. *Southwest Hydrology* 6(5): 26-27,31.

Scott, C.A. 2007. Energy boom and groundwater bust: Mexico's water-energy nexus with implications for the U.S. border region. Presented at First Western Forum on Energy & Water Sustainability, Bren School of Environmental Science & Management, University of California, Santa Barbara, March 22-23, 2007.

Scott, C.A. and T. Shah. 2004. Groundwater overdraft reduction through agricultural energy policy: insights from India and Mexico. *International Journal of Water Resources Development* 20(2): 149-164.

Seidman Research Institute. 2009. An Assessment of the Economic Impacts on the State of Arizona of the Imposition of a GHG Emission Allowance Trading Program. Phoenix: Arizona Investment Council and Arizona State University.

Shah, T., C.A. Scott, J. Berkoff, A. Kishore, A. Sharma. 2007. Energy-irrigation nexus in South Asia: Pricing versus rationing as practical tool for efficient resource allocation. In F. Molle and J. Berkoff (eds.)

Irrigation Water Pricing: The Gap Between Theory and Practice. CAB International, Wallingford, pp. 208-232.

Shah, T., C.A. Scott, A. Kishore, A. Sharma. 2007. Energy-irrigation nexus in South Asia: improving groundwater conservation and power sector viability. In M. Giordano and K.G. Villholth (eds.) The Agricultural Groundwater Revolution: Opportunities and Threats to Development. CAB International, Wallingford, pp. 211-242.

Sivak, M. 2009. Energy-demand consequences of the recent geographical shift in the metropolitan population of the US. *Cities* 26: 359-362.

Skole, D. L. 2004. Geography as a great intellectual melting pot and the preeminent interdisciplinary environmental discipline. *Annals of the Association of American Geographers* 94(4): 739-743.

Smil, V. 2005. *Energy at the Crossroads: Global Perspectives and Uncertainties*. Cambridge: MIT Press.

Sousa, David J. & Christopher McGrory Klyza. 2007. New Directions in Environmental Policy Making: An Emerging Collaborative Regime or Reinventing Interest Group Liberalism? *Natural Resources Journal* 47(2, Spring 2007): 377-444.

Sovacool, B. K., and K. E. Sovacool. 2009. Identifying future electricity–water tradeoffs in the United States. *Energy Policy* 37: 2763–2773.

Trask, Matt. 2005. Water-Energy Relationship: In support of the 2005 Integrated Energy Policy Report. California Energy Commission CEC-700-2005-011 (June 2005).

United Nations (UN) Population Division. 2008. *World Urbanization Prospects: The 2007 Revision – Highlights*. New York: United Nations.

Veerapaneni, Srinivas, Bruce Long, Scott Freeman, and Rick Bond. 2007. Reducing energy consumption for seawater desalination. *Journal of the American Water Works Association* 99(6): 95-106.

Water Center at Colorado State University. 2005. Colorado Water Newsletter (June 2005).

Webb, Erik K. 2006. Directions in National Water Research Policy and Funding. *Journal of Contemporary Water Research & Education*, 134: 51-57 (July 2006).

Wilkinson, Robert C., 2007. Integrating Water and Energy Resource Management: Progress and Opportunities. American Society of Civil Engineers, World Environment and Water Resources Congress.

Wilkinson, Robert C., Fawzi Karajeh, and Julie Mottin, 2005. *Water Sources "Powering" Southern California: Imported Water, Recycled Water, Ground Water, and Desalinated Water: An Analysis of the Energy Intensity of Water Supplies for the West Basin and Central Basin Municipal Water Districts*.

Wilkinson, Robert C., Gary Wolff, William Kost, Rachael Shwom. 2006. An Analysis of the Energy Intensity of Water in California: Providing a Basis for Quantification of Energy Savings from Water System Improvements. American Council for an Energy Efficient Economy.