**TIM 155: Water and Energy Management**

**Spring quarter 2017; Tuesday/Thursday 9:50 – 11:25 am; EMS B210**

**Course website:** [https://tim155-spring17-01.courses.soe.ucsc.edu/](https://tim155-spring17-01.courses.soe.ucsc.edu/" \t "_blank)

Instructor: Brent M. Haddad, Ph.D. [bhaddad@ucsc.edu](mailto:bhaddad@ucsc.edu) Office hours: Wednesdays noon-2 pm Engineering 2, Room 567, and by appointment.

**Introduction.** Well-managed energy and water systems are vital to the economy, public health, and environmental protection. Management challenges including operating at affordable cost, minimizing environmental impacts, meeting growing/shifting demand patterns, upgrading aging infrastructure, maintaining sufficient supply and quality, and maintaining a skilled workforce. This class introduces energy and water management challenges and explores techniques for understanding them better and generating recommendations and actions. While also providing overviews of the water and energy sectors, the course focuses on areas of intersection where each sector strongly influences the other.

**What you will learn.** The course presents current water and energy production and consumption trends, resource systems overview, and current and emerging resource-management challenges. The course introduces energy and water modeling techniques that can help decision-makers understand their management choices. Techniques include the NREL SAM renewable energy model, and a water ratemaking model.

**Grading.** 72% homework sets. Homework is ***due at the beginning of class on Thursdays*** every week, starting week 2 through week 10, a total of nine assignments. (The first homework is due on Thursday, April 13.) Each assignment is worth 8% of the overall grade. Homework is due in class on paper at the beginning of class on Thursdays. *Late Homework Policy*: Homework turned in by 4 pm the following day (Friday) has its score reduced by 20%. Homework turned in past 4 pm receives no credit.

28% Final Exam (Tuesday, June 13, 4:00 – 7:00 pm). The final exam covers the entire quarter – lectures, readings, in-class projects and homework. The exam will be part recall and part analysis.

**Readings**

The following readings will be used in the course. The abbreviation in bold is used below.

**(GEA)** GEA, 2012: *Global Energy Assessment - Toward a Sustainable Future*. International Institute for Applied Systems Analysis, Vienna, Austria and Cambridge University Press, Cambridge, UK and New York, NY, USA.

**(USDOE)** U.S. Department of Energy, 2014. *The Water-Energy Nexus: Challenges and Opportunities*. Washington, D.C.: Department of Energy.

**(USEIA)** U.S. Energy Information Administration, 2017. *Annual Energy Outlook 2017.* https://www.eia.gov/outlooks/aeo/

Additional articles are also assigned.

**Week 1: Introduction to Energy and Water**

Reading (by Thursday April 6):

**USDOE**, Executive Summary.

USEPA, 2015. *How we use water in these United States.* 10 pp. Website downloaded 10-1-15.

**USEIA**, Overview and key takeaways, pp. 4-30.

In class projects: ­

Exploring links between economic activity and power and water consumption

**USDOE** Figures ES3 and ES4 – understanding them in detail

**Week 2: Primary and secondary sources of energy**

Reading (due by Tuesday):

**GEA**, Ch. 1, Ch. 12.2

In class projects:

Understanding GEA figures 1.5, 1.16, and 1.28.

Regional energy input and output modeling

**Week 3: Energy systems**

Reading:

**GEA**, Ch. 15

Energetics, Incorporated, 2015. Energy-Positive Water Resource Recovery: Workshop Report. April 28-29, 2015. Executive Summary and pp. 1-22.

In class project:

Review **GEA** figures 15.4, 15.6, 15.10, 15.11, 15.13, 15A.2

**Week 4: Sources and uses of water**

Reading:

Food and Agriculture Organization (FAO), 2003. *Review of World Water Resources*. Water Reports #23. Rome: FAO. Focus on chapters 2 and 3; appreciate the rest.

United Nations 2016. *World Water Development Report: Water and Jobs*. Chapter 2 and chapters15-17.

In class project:

How much water is needed on earth? How will we get it?

**Week 5: Climate change, energy, and water**

Reading:

**USDOE**, Chapter 3

**GEA**, Ch. 13, focusing on 13.2 and 13.4.

Paris Agreement: http://unfccc.int/paris\_agreement/items/9485.php

In class project:

The Paris Agreement – what does it mean?

**Week 6: Renewable Energy 1/2**

Reading:

Lovins, A. 1976. Energy Strategy: the Road Not Taken? *Foreign Policy* (October).

**GEA**, Ch. 11 (Executive Summary, Sections 11.1, 11.10, 11.11.5, and **two** of sections 11.2 through 11.9.

Visit and browse:

the Greentech Media site: [www.greentechmedia.com](http://www.greentechmedia.com)

In class project:

NREL SAM model version 2017.1.17 (National Renewable Energy Laboratory System Analysis Model)

**Week 7: Renewable Energy 2/2**

Reading:

**GEA**, Ch. 11, two additional sections of 11.2 through 11.9.

In class project:

NREL SAM model, continued.

**Week 8: Water Finance and Ratemaking**

Reading:

Portfolio of readings on City of Santa Cruz ratemaking study, available on website

In class project:

Water Utility Ratemaking Model

**Week 9: Urban Water Reuse Guest Lecturer: Audrey Levine**

Readings:

Levine, A., and Asano, T. 2004. “Recovering Sustainable Water from Wastewater,” *Environmental Science and Technology.* **38:11** 201A-208A, June 1.

Committee on the Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs, 2012.  *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater*.  Washington, D.C.: National Academies Press. Chapters 1 and 2.

**Week 10: Water and energy in combination**

Reading:

US Department of Energy (USDOE). 2006. “Energy Demands on Water Resources.” Report to Congress on the interdependency of energy and water.”

**USDOE,** Ch. 2

In class project:

**USDOE** Appendix A – the “Sankey Diagram”

**Final Exam:** Tuesday, June 13, 4:00 – 7:00 pm