**TIM 155: Data Analytics for Water and Energy Management**

**Winter quarter 2015; Tuesday/Thursday 10:00 – 11:45 am; Porter Academic Building 241**

Instructor: Brent M. Haddad, Ph.D. [bhaddad@ucsc.edu](mailto:bhaddad@ucsc.edu) Office hours: Thursdays 2-4 pm Engineering 2, Room 567, and by appointment.

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**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, and maintaining a skilled workforce. This class introduces energy and water management challenges and explores techniques for understanding them better and generating recommendations.

**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, Theis method groundwater modeling, and a water ratemaking model.

**Grading.** 72% homework sets. Homework is ***due by Thursday at 4 pm*** every week, starting week 2 through week 10, a total of nine assignments. (The first homework is due on Thursday, January 14.) Each assignment is worth 8% of the overall grade. Homework can be turned in in class, dropped off at Professor Haddad’s office hours, or emailed to Professor Haddad. *Late Homework Policy*: Homework turned in by 4 pm the following day (Friday) loses 10% of total points available.

28% Final Exam. 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, 2015. *Annual Energy Outlook.* DOE/EIA0383(2015).

Additional articles are also assigned.

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

Reading (by Thursday January 7):

**USDOE**, Executive Summary.

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

**USEIA**, Executive Summary

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):

**USEIA**, pp. 1-27

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

In class projects:

Understanding USEIA Tables A1 and A2 (starting on pdf p. 51)

Understanding GEA figures 1.5, 1.16, and 1.28.

**Week 3: Energy systems**

Reading:

**GEA**, Ch. 15

In class project:

Review **GEA** figure 15.4 and figure 15.6

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

Reading:

Food and Agriculture Organization (FAO), 2003. *Review of World Water Resources*. Water Reports #23. Rome: FAO.

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.

In class project:

The Paris Agreement – what does it mean?

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

Reading:

**GEA**, Ch. 11 up through 11.4 (p. 811)

Recommended: <https://www.youtube.com/watch?v=0qtlzkU5wEM>

<https://sam.nrel.gov/node/69635>

Visit and browse:

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

the Cleantechnica site: <http://cleantechnica.com/>

In class project:

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

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

Reading:

**GEA**, Ch. 11, starting at 11.5 to finish.

In class project:

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

**Week 8: Water Finance and Ratemaking**

Reading:

Portfolio of readings on City of Santa Cruz ratemaking study

In class project:

Water Utility Ratemaking Model

**Week 9: Water availability and quality**

Reading:

Zhou, Yangxiao, and Li, Wenpeng, 2011. A review of regional groundwater flow modeling. *Geoscience Frontiers* 2(2) 205-214.

*Radial Flow to Wells* reading

In class project:

Modeling well dynamics

**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:** Monday, March 14, 12:00 – 3:00 pm.