Course Syllabus

WEN614 – Sustainable Desalination Processes

Water and Environmental Engineering Program

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1 Overview

1.1 Overview

The course introduces key issues related to promoting sustainable desalination operations in today's desalination industry. The course analyzes developments in the desalination industry using the three elements of sustainability: cost, society, and the environment. The aim of this course is to help the students approach the desalination industry with sustainability in mind. As the desalination industry booms and new desalination-related systems, designs, processes and products are introduced every year, these new developments could best be judged by their sustainability. In this context, the course covers topics such as environmental impacts of desalination processes, understanding water production via desalination within the water-energy-cost nexus, designing safe and sustainable intake and outfall systems for desalination plants, assessing economic feasibility of new desalination processes, evaluation of renewable-energy-powered desalination processes, evaluation and applications of novel desalination systems, such as membrane distillation and forward osmosis, recent technological improvements for enhanced desalination processes, and fouling issues in RO membranes. To better convey the course concepts, case studies will be presented.

1.2 Learning Outcomes and Assessment Methods

1.2.1 Learning Outcomes

1. Understand the concept of sustainability in the context of desalination processes
2. Comprehend the environmental impacts of various desalination processes
3. Awareness of issues related to designing sustainable intake and outfall discharge systems for desalination plants
4. Ability to perform basic economic analyses to evaluate and compare desalination processes
5. Understand heat and mass transfer in new desalination processes such as membrane distillation
6. Familiarity with recent trends and developments in the desalination industry and the understanding of how they can be judged using the three sustainability components

1.2.2 Assessment Methods

There are no traditional "exams" in this course. Assessment is done through homework assignments (mini-projects) and one main project. Several homework assignments will be given during the semester. These will be in the form of intensive mini-projects with relevance to course subjects. Students will do their homework assignments individually. The course project will be assigned to individuals or small groups of students (depending on class size) early in the semester. All effort will be made for students to be assigned individual projects. However, in the case of group projects, which will have no more than 2 students, the students will be asked to develop a project plan with clear responsibilities for each participant. The students will work on their project throughout the course and present their results. Grading of course project will be based on presentations as well as written reports.

1.2.3 Course Readings

Because the course covers a broad range of topics, there is no single comprehensive textbook. Thus, for course readings, students will be expected to consult the reading materials, which will be provided on the course web site, additional references from the library, as well as lecture slides for the course, which will also be provided on the course web site. A partial reading list is provided at the end of this syllabus.

1.3 Grading Policy

Grades will be based on various assignments throughout the term. Their weights are:

- HW Assignments (mini-projects): 60%
- Course project-Report: 25%
- Course project-Oral presentation: 15%

Since the grading in this course will be done based on homework assignments and course project, it is very important that the students be familiar with the criteria applied when grading each of these assignment types. They are as follows:

Homeworks: the main criteria for HW grading are:

- Analytical and critical comprehension and presentation of information
- Relevance of presented information
- Accuracy of calculations (for HWs involving calculations)
- Completeness and accuracy of provided answers
- Validity and justification of assumptions, when made.
- Thoroughness in searching the information (but without exceeding page limits)
- Reflection of good understanding and application of course concepts taught in the HW assignment

Project: the main criteria for project grading are:

- Reflection of good understanding and application of course concepts taught in the project
- Inclusion of the three sustainability elements in the discussion
- Thoroughness in collecting relevant and useful data
- Legitimacy of assumptions (if any) and their justification
- Quality and depth of results discussion
- Final recommendations (logic, clarity, support within study)
- Discussion of study limitations
- Data presentation (clarity, effectiveness, etc)
- Report formatting (including citations, language, effective utilization of page limit, etc)
- handling questions (during oral project presentations)

1.3.1 Absences

Students are expected to complete all assignments on time. Unexcused late assignments will be marked down. Reasonable excuses (sickness, unavoidable professional absences, family emergencies, etc.) will of course be accepted when presented near the event.

1.3.2 Academic Honesty:

Assignments turned in for grading are to be done individually, although it is expected that students will discuss the issues involved in problem sets and often learn best collectively. In practice this means that students may lead each other to the proper understanding of the material, but should ultimately prepare reports for each assignment individually, in their own format and words. Demonstrated evidence of copying (exactly the same wording of sentences, etc.) will result in zeros for each paper with this evidence.

1.4 Class Schedule Spring 2013

Class	Date	Day	Topic	Homework assigned	Homework Due
1	20/1	Sunday	Course Introduction		
2	23/1	Wednesday	The global water crisis	HW 1	
3	27/1	Sunday	The desalination market		
4	30/1	Wednesday	Desalination and sustainability	HW 2	HW 1
5	3/2	Sunday	Fouling in RO plants		
6	6/2	Wednesday	HW2 presentations and The red tide phenomena-1	HW 3	HW 2
7	10/2	Sunday	The red tide phenomena-2		
8	13/2	Wednesday	HW3 presentations and course project introduction		HW 3
9	17/2	Sunday	safe and sustainable intake and outfall systems	HW 4	
10	20/2	Wednesday	Environmental impacts of desalination processes-1		
11	24/2	Sunday	Environmental impacts of desalination processes-2		HW 4
12	27/2	Wednesday	Environmental impacts of desalination processes-3		
13	3/3	Sunday	Renewable-energy powered desalination-1: Introduction to solar energy		
14	6/3	Wednesday	Renewable-energy powered desalination-2: PV-RO systems		
15	10/3	Sunday	Renewable-energy powered desalination-3: Low capacity solar thermal desalination systems	HW 5	
16	13/3	Wednesday	Renewable-energy powered desalination-4: High capacity solar thermal desalination systems		
17	17/3	Sunday	Novel desalination technologies: membrane distillation-1		
18	20/3	Wednesday	Novel desalination technologies: membrane distillation-2		
19	24/3	Sunday	Novel desalination technologies: membrane distillation-3		HW 5
20	27/3	Wednesday	Assessing economic feasibility of new desalination processes-1		
	31/3	Sunday	No class. Mid-semester break		
	3/4	Wednesday	No class. Mid-semester break		
	7/4	Sunday	No class. Mid-semester break		
	10/4	Wednesday	No class. Mid-semester break		
21	14/4	Sunday	Assessing economic feasibility of new desalination processes-2	HW 5	
22	17/4	Wednesday	Assessing economic feasibility of new desalination processes-3		
23	21/4	Sunday	Movie: the blue wars		

24	24/4	Wednesday	Recent advances in desalination		
25	28/4	Sunday	The Singapore experience: NEWater		
26	1/5	Wednesday	TBD: The Boron issue in desalination OR Novel desalination technologies: Forward osmosis		HW 6
27	5/5	Sunday	Project presentations		
28	8/5	Wednesday	Project Presentations		
	12/5	Sunday	No class. Final exams week		
	16/5	Thursday	No class. Final exams week		

1.5 Other logistics

1.5.1 Class time/location

Sunday-Wednesday, Classroom 2, 4:15-5:30 PM

1.5.2 Office hours:

Due to the dynamic nature of the work at Masdar Institute (meetings, research activities, etc), setting office hours that cannot be broken may be difficult. So, the students are welcome to stop by the Dr. Arafat's office at any time for questions, etc. If the student prefers to setup an appointment beforehand with Dr. Arafat, that would also be fine.

1.6 Reading List

- "Desalination Technology: Health and Environmental Impacts", Joseph Cotruvo, Nikolay Voutchkov, John Fawell, Pierre Payment, David Cunliffe, Sabine Lattemann, CRC Press, 2010.
- "Energy, Water Resources and sustainability in the Arab World: Perspective and Prognosis", Hickmet Shaban, Book Surge Publishing, 2008.
- "Seawater Desalination: Conventional and Renewable Energy Processes", Andrea Cipollina, Giorgio Micale, Lucio Rizzuti, Springer, 2009.
- "Membrane Distillation: Principles and Applications", M. Khayet and T. Matsuura, Elsevier, 2011.
- "Solar Desalination for the 21st Century: A Review of Modern Technologies and Researches on Desalination Coupled to Renewable Energies (NATO Security through Science Series C: Environmental Security)", Lucio Rizzuti, Hisham M. Ettouney, and Andrea Cipollina, Springer, 2007.
- "Sustainable Water for the Future, Volume 2: Water Recycling versus Desalination", Isabel C. Escobar, Andrea Schaefer, Elsevier, 2009.
- "Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges, Executive Summary", The Johnson Foundation, 2010
- "A comprehensive review of nanofiltration membranes: Treatment, pretreatment, modeling, and atomic force microscopy", N. Hilal, H. Al-Zoubi, N.A. Darwish, A.W. Mohammad, M. Abu Arabi, Desalination 170 (2004) 281–308

- “MSF-SYSTEM: PRESENT STATUS AND FUTURE DIRECTION”, Roberto Borsani, Technical Director - FisiaItalimpianti – Italy, 2010
- “Forward osmosis: Principles, applications, and recent developments”, Tzahi Y. Cath, Amy E. Childress, Menachem Elimelech, Journal of Membrane Science 281 (2006) 70–87.
- “Concentrating Solar Power for Seawater Desalination, Final Report” by German Aerospace Center (DLR) Stuttgart, November 2007
- “Desalination for Safe Water Supply, Guidance for the Health and Environmental Aspects Applicable to Desalination” Public Health and the Environment, World Health Organization, Geneva 2007
- “Distillation plant development and cost update”, Neil M. Wade, Desalination 136 (2001) 3–12
- “Development of a fourth generation energy recovery device: A 'CTO's Notebook”, Richard L. Stover, Desalination 165 (2004) 313-321
- “Exergy analysis of a combined RO, NF, and EDR desalination plant”, Nafiz Kahraman, Yunus A. Cengel, Byard Wood, Yunus Cerci, Desalination 171 (2004) 217–232
- Current Patents of Forward Osmosis Membrane Process, Leilei Liu, Meng Wang, Duo Wang and Congjie Gao, Recent Patents on Chemical Engineering, 2009, 2, 76-82
- “Estimating the costs and health benefits of water and sanitation improvements at global level”, Laurence Haller, Guy Hutton and Jamie Bartram, Journal of Water and Health, 05.4, 2007.
- “AN INNOVATIVE APPROACH TO URBAN WASTEWATER TREATMENT IN THE DEVELOPING WORLD”, D. R. F. Harleman and S. Murcott, Water 21: Magazine of the International Water Association, June, 2001
- “First experimental results of a new hybrid solar/gasmulti-effect distillation system: the AQUASOL project”, Diego-César Alarcón-Padilla, Julián Blanco-Gálvez, Lourdes García-Rodríguez, Wolfgang Gernjak, Sixto Malato-Rodríguez, Desalination 220 (2008) 619–625
- “A framework for better understanding membrane distillation separation process”, M.S. El-Bourawi, Z. Ding, R. Ma, M. Khayet, Journal of Membrane Science 285 (2006) 4–29
- “PV and thermally driven small-scale, stand-alone solar desalination systems with very low maintenance needs”, Hassan E.S. Fath, Samy M. Elsherbiny, Alaa A. Hassan, Matthias Rommel, Marcel Wieghaus, Joachim Koschikowski, Mostafa Vatansever, Desalination 225 (2008) 58–69
- “Review of Water Resources and Desalination Technologies”, James E. Miller, Sandia national Lab REPORT: SAND 2003-0800, March 2003
- “Introduction To Physical Oceanography”, Robert H. Stewart, Department of Oceanography, Texas A & M University, 2007
- “Solar desalination with a humidification–dehumidification technique — a comprehensive technical review”, Sandeep Parekh, M.M. Farid, J.R. Selman, Said Al-Hallaj, Desalination 160 (2004) 167–186
- “State-of-the-art of reverse osmosis desalination”, C. Fritzmann, J. Löwenberg, T. Wintgens, T. Melin, Desalination 216 (2007) 1–76

- “Thermophysical properties of seawater: a review of existing correlations and data”, Mostafa H. Sharqawy, John H. Lienhard V, Syed M. Zubair, Desalination and Water Treatment 16 (2010) 354–380
- “Treating Sewage For Drinking Water: New California plant cleanses water to replenish supply”, Chemical & Engineering News, Science & Technology, 2008, 86(4), 71-73

1.7 Acknowledgements

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