

The Greening of the Data Center (NCRT710) Syllabus

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Online office hours via chat: Tuesday 8:00PM-9:00PM Eastern
or by appointment

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What this Class is About

This class is about improving environmental performance in the data center. It will focus primarily on the data center power and cooling facilities and ways to operate them in an energy efficient manner. Upon completion of this class, you will:

- 1) Have a historical awareness on energy consumption in the information technology (IT) industry.
- 2) Know what metrics are used and how to assess energy efficient deployment of IT equipment.
- 3) Gain a basic background in electrical concepts that are relevant to the data center.
- 4) Be able to assess existing data center **electrical** subsystems for energy efficiency and work with facilities designers in order to design new data centers with energy efficient **electrical** subsystems.
- 5) Gain a basic background in thermodynamic concepts that are relevant to the data center.
- 6) Be able to assess existing data center **cooling** subsystems for energy efficiencies and work with facilities designers in order to design new data centers with energy efficient **cooling** subsystems.
- 7) Be able to lay out IT equipment racks and cooling units in the data center for high energy efficiency.

This class will include fundamental sessions on power and cooling systems in the data center, so no prior experience is required in these areas (although prior experience would be helpful).

The Learning Process

This course will consist of 10 weekly sessions. Each session will consist of lecture notes as well as outside reading assignments. These reading assignments will be softcopy (i.e. available on the internet). Sessions will usually contain mandatory readings from

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multiple online sources. Each session will have a list of external links that will reinforce the lecture notes. These links may be mandatory or optional readings. Some of the optional readings will include material more advanced in nature, which will be useful if you found the base material too easy.

There is no formal text, but the following includes most of the required reading for the class:

[High Performance Data Centers](#) is available online without charge, published by Lawrence Berkley National Labs. This is the closest thing we have to a text.

There will be no mandatory reading from the following texts, but they are excellent references for the class.

[Design Considerations for Datacom Equipment Centers](#) published by ASHRAE, ISBN/ISSN 1-931862-94-X. This book gives a background in data center cooling fundamentals. We cover some of this in class, but if you are new to data center facilities, this is a worthwhile book to own.

[Best Practices for Datacom Energy Efficiency](#) published by ASHRAE, ISBN/ISSN: 978-1-933742-27-4. This book covers in detail much of the energy saving ideas we cover in class. It is a must have if you manage a data center and want to improve its energy efficiency. It assumes the reader is already experienced in facilities cooling.

You may purchase these [books directly from ASHRAE](#) hardcopy or softcopy for about \$55 each.

Online teaching is tricky business. Body language and facial expressions are important feedback to me on how well you are learning the material. Since these are not available to me, I will need to rely more directly on your feedback. For this reason I expect everyone will be participating in discussion boards made available as part of the curriculum.

Grading

At the conclusion of each session will be a quiz. The quiz will be multiple choice, typically around 10 questions. Quizzes *must be completed in the allocated time period*; there will be no make ups if you do not complete the quiz on time. Please check the class calendar and announcements for the quiz dates. Class participation in the discussion forums will count as one quiz, so you will end up with 11 quiz grades.

Your grade will be determined by the average score of the highest 10 weekly grades. You must take the quiz without help from others but may use any resources you wish to complete the quizzes. The correct answers will be covered in the mandatory reading material in each session. Since missed quizzes count as a zero, the first missed quiz can

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be used as your low grade (and dropped), but a second or subsequent missed quiz will go into the 10 quiz average.

This course is being offered pass/fail. An average of 70% or greater is required for a passing grade.

Discussion Forums

There will be at least 3 discussion forums for the class. Your class participation grade will be dependent on your participation in these forums. The first forum is called 'weekly discussions'. The 'weekly discussions' forum will be our main area of exchange on each week's lesson and students are encouraged to check this frequently (several times every week). Frequent and timely exchange on this forum is needed since we only spend one week on each session. The second forum covers quizzes. In the event you do not understand the solution to any of the quizzes, this is the forum where we discuss the quiz answers. Please keep posts on these first two forums on topic. Additionally there will be a 'green open discussion' forum in the event you want to discuss something related to green data centers that is or has not yet been covered in the class. Watch for announcements on any other forums that may be added.

Session Details

The ten weekly sessions will be broken out as follows:

Session #	Start Date	Topic
1	8-Sept	Why Green Data Centers?
2	15-Sept	The Demand Side
3	22-Sept	Electrical Fundamentals
4	29-Sept	Energy Efficient Electrical Power
5	6-Oct	Cooling Fundamentals
6	13-Oct	Cooling in the Raised Floor Area
7	20-Oct	Air Flow Management
8	27-Oct	Economizers and Chillers
9	3-Nov	Measurement and Automation
10	10-Nov	Miscellaneous Topics

Session 1 will focus on trends in the computer industry. It will cover a historical perspective of power consumption in IT equipment. This is the background information that validates the need to address energy efficiency in the data center.

Session 2 will be on energy efficient deployment of IT equipment. It is beyond the scope to discuss server consolidation and virtualization in detail. However, these topics are so vital to reduced energy consumption; they will be discussed at a high level along with other aspects of the IT equipment itself that can reduce energy consumption.

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Sessions 3 & 4 will be on electrical power. We will cover fundamental electrical concepts in these sessions and learn how to do simple power calculations. We will discuss facilities electrical systems and areas to focus on for energy efficiency.

Sessions 5-8 will be on cooling. The cooling systems in data centers are more complex to operate efficiently than the electrical systems; this is the area where many data centers can see substantial improvements. We will cover basic thermodynamic principals needed for data center cooling, including the refrigeration cycle. We will discuss the components in these systems, including chillers, pumps, economizers and how they may be operated most efficiently. The layout of the IT racks and Computer Room Air Conditioning (CRAC) units are an important part of energy efficient cooling deployment and this will be covered in detail.

Measurement and Automation are becoming ever more important for optimal efficiency in data centers and this will be covered in session 9. We will discuss existing and emerging technologies that will allow for increased efficiency of both the IT equipment and the facilities power and cooling systems.

The 10th and final session will be miscellaneous topics. This will include on site power generation, and environmentally conscious disposal of equipment.