Introduction to Building Simulation and EnergyPlus

Undergraduate Course Curriculum Information

July 31, 2003

Intent

The intent of this document is to present a draft curriculum outline for an undergraduate course that teaches the student about the usage of EnergyPlus. While not all of the curriculum will necessarily be specific to the EnergyPlus program, the vast majority is intended to instruct the student on how EnergyPlus works and what information it needs as input and provides as output.

Assumptions

Every university is slightly different in how it approaches courses, and every instructor will approach a course differently as well. Several assumptions will be made that will help focus the development of this course:

- This course is intended to be taught primarily to upper-level undergraduate students at the (USA) university level but could also be taught at the graduate level.
- The primary audience is a student in mechanical or architectural engineering who has had background courses in heat transfer and thermodynamics. Instructors in affiliated fields such as civil engineering, architecture, etc. may need to supplant some of the lecture material with more basic information on heat transfer, thermodynamics, engineering analysis, etc.
- This course is designed for a university on the semester system where a semester lasts approximately 15 weeks.
- The lectures will be designed for a traditional 50-minute lecture period and three class sessions per week will be assumed.
- It is imperative that students spend supervised time in computer laboratories to gain more experience using the program and the input language. Thus, some of the class periods will be assumed to meet in a computer laboratory rather than a lecture hall.
- Based on the assumptions of 15 weeks and 3-50minute class periods per week, a total of 45 class sessions are available for course introduction, lectures, laboratories, reviews, exams or presentations, etc.
- Since there is currently no interface for EnergyPlus, the lectures will be developed without referring to any interface. The IDF Editor and EP-Launch can be used in computer laboratories as desired. Existing templates may also be utilized.
- Complete expertise in EnergyPlus cannot be gained in a single semester. Thus, this course will strive to give the student a working knowledge of most features of

the program rather than expertise in a specific area. Again, no interface will be assumed (this affects what material must be covered in the lectures).
- Lectures must also provide adequate enough background about what is being simulated so that the students understand "what" not just "how".

General Breakdown of Class Sessions

Based on the assumptions listed in the previous section, the following breakdown of the 45 class sessions can be made. The main focus of this project is to develop the lectures and example assignments. Course syllabi, exams, homework assignments, reviews, course evaluations, etc. are left to the discretion of the individual instructors who will have specific ideas, formats, etc. about what these should be and look like.

- Course Syllabus and Class Overview—1 Session
- Formal Lectures (PowerPoint Slide Shows Provided)—26 Sessions
- Computer Laboratories (Example Exercises to be developed by Instructor, see section later in this documents for more notes on this)—14 to 15 Sessions, some of which may be used as semester project work sessions
- Exams and/or Presentation of Semester Projects—2 to 3 Sessions
- Final Review, Course Evaluations, Wrap-up—1 Session

Class Outline/Schedule (With Semester Projects)

In many cases, the lessons learned and knowledge gained by a course in EnergyPlus is best applied not only through application assignments but also a semester project that deals with using EnergyPlus. The main goal would be to demonstrate the use of EnergyPlus to model an existing building or a building design. Instructors could also require students to compare the results with measured building data and/or perform the analysis or retrofit or design options to improve the overall performance of the building. The following schedule is intended to work with a course that uses a project to test student comprehension rather than exams. Obviously, individual instructors are free to adapt the schedule and lecture material as they see fit. In some cases, instructors may wish to use the example assignments sparingly and focus more on student projects. Note that an accompanying spreadsheet contains the number of slides for each of the individual lectures. Note that some lectures are too long to cover in one hour and this may require an adjustment of the schedule. Lectures 4 and 14 are examples of lectures that may require two hours to cover. Again, discretion is left up to the individual instructor as to whether material will be skipped or lectures will be enhanced. Thus, the schedule is merely a starting point that will need to be customized. Computer laboratories may include activities other than input file creation (such as looking up and/or downloading weather data or documentation, research on materials or construction techniques, etc.)

Week	Class Type	Description
Week 1	General	Class Overview and Discussion of Course Syllabus

Week 1	Lecture 1	EnergyPlus Overview (Program History, Files Overview, Web Resources)
Week 1	Computer Laboratory 1	Intro to/Demo of IDF Editor/EP-Launch/Install
Week 2	Lecture 2	Running EnergyPlus and Output
Week 2	Lecture 3	Output Variables, Meters, Reports
Week 2	Computer Laboratory 2	Introduction to Output
Week 3	Lecture 4	Simulation control, weather, location, ground temperature
Week 3	Lecture 5	Materials, Constructions, Surfaces, Zones, Buildings
Week 3	Computer Laboratory 3	Run Control and Weather Information Exercise
Week 4	Lecture 6	Materials, Constructions, Surfaces, Zones, Buildings
Week 4	Lecture 7	Building Modeling Questions
Week 4	Computer Laboratory 4	Building Envelope Exercise
Week 5	Lecture 8	Schedules, Internal Gains, Infiltration
Week 5	Lecture 9	Windows, Daylighting
Week 5	Computer Laboratory 5	Scheduled Heat Gains and Zone Controls Exercise
Week 6	Lecture 10	Zone and Modeling Controls, Purchased Air
Week 6	Lecture 11	Simple Ventilation, Mixing/Cross Mixing, COMIS
Week 6	Computer Laboratory 6	Windows and Daylighting Exercise
Week 7	Lecture 12	Green Input: Trombe Wall, Movable/Transparent Insulation, Thermal Mass, etc.
Week 7	Lecture 13	Loops, Nodes, Branches, Connectors
Week 7	Computer Laboratory 7	Air Movement and Green Features Exercise
Week 8	Lecture 14	Air Loops and Zone Equipment
Week 8	Lecture 15	Air Loops and Zone Equipment
Week 8	Computer Laboratory 8	Semester Project Work Session
Week 9	Lecture 16	Air Loops and Zone Equipment
Week 9	Lecture 17	Air Loops and Zone Equipment
Week 9	Computer Laboratory 9	Air Loops and Zone Equipment Exercise
Week 10	Lecture 18	Templates and Autosizing
Week 10	Lecture 19	Outside Air
Week 10	Computer Laboratory 10	Semester Project Work Session
Week 11	Lecture 20	Radiant Systems
Week 11	Lecture 21	Plant/Condenser Loops and Equipment
Week 11	Computer Laboratory 11	Radiant System Exercise
Week 12	Lecture 22	Plant/Condenser Loops and Equipment
Week 12	Lecture 23	Plant/Condenser Loops and Equipment
Week 12	Computer Laboratory 12	Plant and Condenser Loop Exercise

Week 13	Lecture 24	Ground Heat Transfer
Week 13	Lecture 25	TBD or Catch up/Lecture 4b
Week 13	Lecture 26	TBD or Catch up/Lecture 14b
Week 14	Computer Laboratory 13	Semester Project Work Session
Week 14	Computer Laboratory 14	Semester Project Work Session
Week 14	Computer Laboratory 15	Semester Project Work Session
Week 15	Project Presentations	In-Class Presentations By Students
Week 15	Project Presentations	In-Class Presentations By Students
Week 15	General	Final Review, Course Evaluations, Class Wrap-up

Class Outline/Schedule (With Exams/Quizzes)

The content and goals for this class are the same as for the project class except that exams are used to further and test student comprehension of EnergyPlus. However, the schedule is slightly altered to allow time for exams.

Week	Class Type	Description
Week 1	General	Class Overview and Discussion of Course Syllabus
Week 1	Lecture 1	EnergyPlus Overview (Program History, Files Overview, Web Resources)
Week 1	Computer Laboratory 1	Intro to/Demo of IDF Editor/EP-Launch/Install
Week 2	Lecture 2	Running EnergyPlus and Output
Week 2	Lecture 3	Output Variables, Meters, Reports
Week 2	Computer Laboratory 2	Introduction to Output
Week 3	Lecture 4	Simulation control, weather, location, ground temperature
Week 3	Lecture 5	Materials, Constructions, Surfaces, Zones, Buildings
Week 3	Computer Laboratory 3	Run Control and Weather Information Exercise
Week 4	Lecture 6	Materials, Constructions, Surfaces, Zones, Buildings
Week 4	Lecture 7	Building Modeling Questions
Week 4	Computer Laboratory 4	Building Envelope Exercise
Week 5	Lecture 8	Schedules, Internal Gains, Infiltration
Week 5	Lecture 9	Windows, Daylighting
Week 5	Exam 1	
Week 6	Computer Laboratory 5	Scheduled Heat Gains and Zone Controls Exercise
Week 6	Lecture 10	Zone and Modeling Controls, Purchased Air
Week 6	Lecture 11	Simple Ventilation, Mixing/Cross Mixing, COMIS
Week 7	Computer Laboratory 6	Windows and Daylighting Exercise

Week 7	Lecture 12	Green Input: Trombe Wall, Movable/Transparent Insulation, Thermal Mass, etc.
Week 7	Lecture 13	Loops, Nodes, Branches, Connectors
Week 8	Computer Laboratory 7	Air Movement and Green Features Exercise
Week 8	Lecture 14	Air Loops and Zone Equipment
Week 8	Lecture 15	Air Loops and Zone Equipment
Week 9	Computer Laboratory 8	Air Loops and Zone Equipment Exercise
Week 9	Lecture 16	Air Loops and Zone Equipment
Week 9	Lecture 17	Air Loops and Zone Equipment
Week 10	Exam 2	
Week 10	Computer Laboratory 9	Air Loops and Zone Equipment Exercise
Week 10	Lecture 18	Templates and Autosizing
Week 11	Lecture 19	Outside Air
Week 11	Computer Laboratory 10	Air Loops, Templates, and Autosizing Exercise
Week 11	Lecture 20	Radiant Systems
Week 12	Lecture 21	Plant/Condenser Loops and Equipment
Week 12	Computer Laboratory 11	Radiant System Exercise
Week 12	Lecture 22	Plant/Condenser Loops and Equipment
Week 13	Lecture 23	Plant/Condenser Loops and Equipment
Week 13	Computer Laboratory 12	Plant and Condenser Loop Exercise
Week 13	Lecture 24	Ground Heat Transfer
Week 14	Lecture 25	TBD or Catch up/Lecture 4b
Week 14	Exam 3	
Week 14	Lecture 26	TBD or Catch up/Lecture 14b
Week 15	Computer Laboratory 13	Independent Research Assignment
Week 15	Computer Laboratory 14	Independent Research Assignment
Week 15	General	Final Review, Course Evaluations, Class Wrap-up

Lecture Examples and Homework Assignments

Examples and case studies have been used through the lectures to provide the students with some insight into the workings of EnergyPlus and also to initiate discussions between the instructor and the students. The lectures do not claim to be exhaustive in covering every detail that could potentially be investigated or discussed in class. Some examples might be overly complex for some of the students. Instructors may wish to replace examples and case studies with ones from their own course material or create new ones that focus on more specific topics or that allow a particular effect to be analyzed. Instructors may also wish to assign simpler examples or targeted case studies as homework assignments—allowing the students to gain experience with the program and to take time outside of class to think through particular issues involved with simulating buildings.

In addition, while is some cases, instructors will have homework assignments and examples that used other simulation programs which they wish to convert to EnergyPlus examples, other instructors may not have a "library" of examples and homework assignments. The lectures developed for this university course were a part of a larger research project that also developed lectures for professionals. These professional series lectures also included workshops that could be used as homework assignments. Information on where to locate these workshops should be available at the NREL web site.

Concluding Comments

We hope that you enjoy the lectures provided in this course and will find them useful in your teaching efforts. You may only use part of the material for an unrelated course, you may use the lectures as they are, or you may modify/enhance the lectures to suit the particular focus of your course. The authors of this lecture series hope that instructors using these materials will share their experiences and improvements with NREL so that others instructors and the students can benefit from the collective body of knowledge in this area.