Syllabus

ENV 5XXX
Principles of Sustainable Engineering Design

William A. Wallace

Adjunct Lecturer
University of Florida
College of Engineering
Engineering School of Sustainable Infrastructure & Environment
Department of Environmental Engineering Sciences
ENV 5XXX
PRINCIPLES OF SUSTAINABLE ENGINEERING DESIGN

Professor: William A. Wallace
Adjunct Lecturer, EDGE Program
Department of Environmental Engineering Sciences
Engineering School of Sustainable Infrastructure & Environment
32433 SW Lake Drive
Wilsonville, OR 97070
MOBILE: (970) 819-2188
EMAIL: wawallace2@ufl.edu or bill.wallace@wallacefutures.com
Office Hours: Email me or call me any day (8:00 AM to 5:00 PM PT)

OVERVIEW
Why take this course? Here is my course “BHAG,” the acronym for what management authors Jim Collins and Jerry Porras called a Big Hairy Audacious Goal.2

When you complete this course, you will be able to discuss the issues of sustainability confidently with your clients, customers, bosses and friends, and identify opportunities and risks they never imagined they had.

This course is designed to help students navigate through the complex and often confusing issues of sustainability and their relationship to engineering design. Aimed at upper-level undergraduate and graduate students, the course covers a wide range of subjects, including sustainable and unsustainable systems, assessment of ecosystem conditions, the impacts of climate change, the sustainability of nations, the business case for sustainability, sustainable engineering tools and techniques, resilient and sustainable cities, and prospects for a sustainable future. Critical issues of sustainability and its effects on civil infrastructure are explained. Emphasis is given to climate change and how that product of human activity is altering the fundamental assumptions of civil infrastructure design and operation. Tools and methodologies for assessing the effects and impacts, and delivering safe, reliable civil infrastructure projects are also offered. Students completing this course will gain new perspectives on engineering design for sustainability, and how industry and government organizations are incorporating sustainability principles and practices into their operations. Students will also learn why these organizations believe that taking these actions makes good economic and business sense.

This course is tailored to give students considerable flexibility in meeting the course requirements. All the lecture modules (75, averaging 30-minutes each) are pre-recorded and available on the first day of the semester. A list and description of the lecture modules is provided at the end of this syllabus. Students can view these

---

1 This course used to be called ENV6617 Principles of Green Engineering Design.
modules at any time, and at a pace that can adjust to their schedules. To meet course requirements and to hone their writing skills, students prepare three, 5000-word papers on sustainability-related topics. Paper topics are student-selected from a list of over 50 pre-described topics. Alternatively, a student can propose topics that meet his/her own interests and/or field of work or study. Grades for the course will be based primarily (75%) on the three student papers. The remainder of the grade will be based on correct answers to multiple-choice questions about the material covered in the lecture modules.

BACKGROUND
The notion that the society’s form of economic development was not sustainable emerged in the late 1980s. Noting the harmful effects on resources, society and the environment, the United Nation’s Brundtland Commission called for future economic development to be sustainable, i.e., “meet the needs of the present without compromising the ability of future generations to meet their own needs.” The Commission noted that the environment, economy and society were inextricably connected, that is, damages to the environment and its ecological systems also damaged the economy and societal well-being.

Today, we are experiencing the harmful effects of literally centuries of unsustainable behavior. Resources, once thought of as effectively inexhaustible, are now seen as finite and increasingly scarce. Ecological systems, once thought of as essentially boundless, robust and self-repairing, are now seen as limited and already damaged by human activity. Importantly, damage to climate-regulating ecological systems, caused by increased atmospheric concentrations of greenhouse gases, has resulted in a changing climate. That change is altering significantly the environmental conditions under which civil infrastructure is expected to operate. Consequently, long-held engineering design assumptions such as expected ambient temperatures, sea levels, storm intensity, and the extent of droughts and heat waves are no longer reliable. Unknowingly, today’s engineers are planning, designing and constructing infrastructure projects that will not be able to cope with future environmental operating conditions. Infrastructure projects designed to be long-lived are especially vulnerable to these changing conditions.

Owners and overseers of this nation’s infrastructure are responding to these changes in important ways. The U.S. Department of Transportation has produced extensive guidance on assessing infrastructure vulnerability to climate change. The U.S. Environmental Protection Agency has published tools for developing climate resilience for water and wastewater management systems. The UK’s Heathrow Airport has created a framework for assessing operational risk and formulating an effective response to climate change. These are a few examples of how decision-makers are expecting infrastructure projects to be planned, designed and delivered now and in the future. Today’s engineers and practitioners need to meet these expectations to be successful.
In this course, improving the sustainable performance of infrastructure is not treated as how to insert so-called “green” add-ons to traditional designs. Instead, sustainable engineering is treated as the management of change. Conditions of non-sustainability are, in effect, creating a “new normal” in terms of operating conditions and performance requirements. Traditional assumptions about averages, variances and plausible extremes for design variables are no longer reliable. This course will identify and assess these areas of change and offer a corresponding engineering design approaches to effectively manage this change.

The effects and consequences of non-sustainable behavior on nations (developed, developing, and underdeveloped) are also presented along with their respective challenges and considerations in engineering design. How industry and government sectors have responded will also be addressed, as these institutions have and continue to drive changes in engineering design and performance criteria associates with sustainability. Their responses and accomplishments will be presented in a business context, showing how these changes relate to competitiveness and improved economic performance.

Tools such as sustainability metrics, life cycle assessment, sustainability auditing and carbon footprinting will be demonstrated. Finally, new techniques for delivering projects that maximize contributions to sustainable performance while accounting for changing environmental operating conditions will be introduced.

**OBJECTIVES OF THIS COURSE:**

- Introduce the concepts of sustainable development and sustainability in its proper form, separating them from the popularized and largely inaccurate notions about being “green” to ones that have a scientific and engineering basis.
- Convey an understanding of what is really required to achieve conditions sustainability through principles such as The Natural Step, and Herman Daly’s thermodynamic definitions of sustainability. Introduce the production-consumption flow model and the Five Capitals model as a way of thinking about sustainability.
- Learn about the trends and forces shaping our world instigated by our non-sustainable economic model for growth and development. Offer a view the salient events in the development of our current concepts of sustainability.
- Learn about the causes, effects, consequences and controversies surrounding global climate change. Understand the mechanisms that are causing global warming. Learn about approaches for addressing climate change: robustness, resilience, redundancy and adaptation. Learn about some of the solutions being proposed, including the ones categorized as geoengineering.
- See the effects of non-sustainability on the developed, developing and underdeveloped nations and learn about the engineering challenges specific to each.
- Characterize the trends and drivers that are shaping industry and governmental responses to the consequences of non-sustainability.
• Learn about the degree to which various industry and government sectors, cities and communities understand the issues and consequences of non-sustainable behavior and how they are responding. Learn how these organizations are incorporating sustainability principles and practices into their operations.
• Define and explore the principles of industrial ecology and by-product synergy and see how they are being applied.
• Survey the current laws, regulations and standards that are being put in place to address the various dimensions of sustainability.
• Learn and place in context the various systems for measuring sustainable performance.
• Gain experience in using the various tools and techniques available for designing and implementing energy conservation measures, conducting life cycle assessments, calculating carbon footprints, and more.
• Learn a new paradigm for achieving improvements in sustainable performance, i.e., the importance of addressing both performance contribution (doing things right) and pathway contribution (doing the right thing) for moving society towards conditions of sustainability. Learn how to increase opportunities for performance improvement. Understand the importance of setting performance objectives that are restorative, not just “less bad.”

WHAT YOU ARE EXPECTED TO KNOW COMING INTO THIS CLASS
A modest understanding of the concepts and issues surrounding sustainable development will be helpful. I will present the facts and figures that make a case that our current model of economic development is not sustainable in its current form. Many charts and graphs of varying complexities will be used to illustrate these points, so basic math skills are required.

I will also be presenting a business case for sustainable development through discussions of how incorporating sustainability policies and practices can improve performance, reduce costs and otherwise make organizations more competitive. Therefore, some understanding of how business and governmental organizations operate will be helpful.

If you are unsure if your qualifications will enable you to be successful in this course, feel free to contact me to discuss. Mobile: (970) 819-2188; email: wawallace2@ufl.edu or bill.wallace@wallacefutures.com

TEXTBOOK FOR THE CLASS
There is no textbook for this class. Instead, I will supply students with a number of publications that contain relevant and current information about the subject. Some of these will be required reading assignments for the course. Others will be references that I thought students should be aware of and could use as general references.
COURSE DELIVERY
The course will be delivered as a series of **75 pre-recorded lectures averaging 30 minutes each**. They are available on the University’s E-Learning website, through the Canvas System. I intend to make all 75 lectures available for viewing at the beginning of the semester. If they are not all available on the first day, it is because I am in the process of updating some of the lectures.

Students should plan to view the course lectures at a pace that will enable them to complete the course within the semester timeframe.

COURSE FORMAT
I have created handouts of the lecture presentations in “PDF” format so that students can print out the handouts to take notes without having to copy information from the slides. Yes, this means that paper will be used. However, your negative impacts on the environment will be negligible compared to the learning benefits. If you find that you still have pangs of guilt after printing the handouts, feel free to plant one or more trees as compensation.

These files will be available on ENV6932 E-Learning site. If you use these handouts, make sure you’re using the latest version of Adobe Reader or a suitable “PDF” file reader.

INSTRUCTOR AVAILABILITY
If you have questions or need help regarding the course or any of the assignments, please contact me. Email is preferable, but telephone calls are also welcome. Students are encouraged to ask questions at any time. If you have questions or just want to discuss the course, please call (8 AM – 5 PM PT) or send me an email. Mobile: (970) 819-2188. Email: wawallace2@ufl.edu or bill.wallace@wallacefutures.com

EXAMS
There are no comprehensive examinations for this course. Final grades will be based on the delivery and achievements on three papers (75%) and the course module quizzes (25%).

QUIZZES
The quizzes consist of one multiple choice question for each module, based on the content of that module. The purpose of these quiz questions is to give assurance that students are progressing through the course. There are no trick questions on these quizzes. Students who viewed the video module and followed the presentation handout should be able to answer the question easily.

PAPERS
Students are required to prepare three (3) research papers on subjects selected by the student from a list of paper topics. The topics are designed to test the student’s grasp of the subject matter and to expand and extend that learning into related areas. The **Paper Topics List** is found in the Syllabus section of the ENV6932 E-Learning
A list and description of topics for these papers is provided on the course website. There are over 50 topics covering a wide range of sustainability issues.

If a student has a specific interest in a particular sustainability topic, which relates to the course material but does not appear on the topic list, he/she can create his/her own topic and submit a short description of that topic to me for approval. Students should not begin work on their self-designed topics without my approval, since the absence of my approval disqualifies the student’s paper from being considered in his/her course grade.

Please note that I am not expecting the papers to be the sort of work product that one would submit to an academic journal. In this course, an “A” graded paper would be a paper that is more or less ready for submission to a popular professional or trade journal, or a report that you would submit to your bosses and discuss with your colleagues.

**Paper requirements and grading criteria**

Guidance for preparing papers are presented in a document called **Paper Preparation Guidelines** located on the course E-Learning website. This document contains a detailed description of what I expect to see in your project report submissions and criteria for how they will be graded. Each paper should be at least 5000 words, not including references. Papers containing less than 5000 words will be downgraded accordingly. I will also downgrade papers that are submitted after the published due date, approximately 1 point per day. Papers submitted more than one week after the published due date will not be graded and will count as a zero in the student’s overall course grade.

**Paper Grading Criteria**

Papers will be graded based on the quality of the content and timeliness of delivery. The due dates for these papers are listed in the class schedule. General criteria for paper grades is presented below.

In order to grade these papers fairly and consistently, I have developed a grading rubric based on writing guidelines and scoring tools used by various colleges and universities to evaluate student writings. This is a methodology that enables me to assign point scores to various aspects of your paper: understanding and analysis, development and support, organization and presentation, and writing mechanics. The scoring also takes into account the basic requirements: timely delivery on or before the due date, and word count, i.e., 5000 words or more.

The rubric is available on the course e-learning website. In addition, I have included several articles and links that offer useful guidance on basic and technical writing.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Researched the topic extensively. Paper is well organized and written, as well as interesting and thought provoking. New knowledge and ideas offered. More-or-less ready for submission to a popular trade journal or presented at a meeting or conference. A few spelling or grammatical errors. &lt;br&gt;( A^+ (100-97) \quad A (96-93) \quad A^- (92-90) )</td>
</tr>
<tr>
<td>B</td>
<td>Got the work done and met the specifications for the report. Good writing. Readable and somewhat interesting. Content is reasonably convincing, backed up by good references. Organization of the paper could use some improvement. Hard to follow the logic. Minor spelling and grammatical errors. Does not meet the 5000-word minimum. &lt;br&gt;( B^+ (89-86) \quad B (85-82) \quad B^- (81-78) )</td>
</tr>
<tr>
<td>C</td>
<td>Wrote on the topic specified but missed the specifications for the paper. Barely sufficient research to support the arguments and conclusions. Writing style is awkward and hard to follow. Organizationally OK but frequently hard to determine what points are being made. Arguments are weak. Proof is slim to none. Some spelling and grammatical errors. Does not meet the 5000-word minimum. &lt;br&gt;( C^+ (77-74) \quad C (73-70) \quad C^- (69-66) )</td>
</tr>
<tr>
<td>D</td>
<td>What is written is generally not on point. Hard to determine what the person is writing about. Content is marginal. Mostly stream-of-consciousness writing. Not well researched. Does not meet the 5000-word minimum. Many spelling and grammatical errors. &lt;br&gt;( D^+ (65-62) \quad D (61-58) \quad D^- (57-56) )</td>
</tr>
<tr>
<td>E</td>
<td>Missed the point of the topic. Content has multiple inaccuracies. Statements not supported. Organization of the report is hard to follow. Conclusions don’t follow the content. Poorly edited. Does not meet the 5000-word minimum. Spelling and grammatical errors abound. &lt;br&gt;( E (\leq 55) )</td>
</tr>
</tbody>
</table>

**ACADEMIC HONESTY**

All students are expected to exhibit academic honesty and abide by the University's Honor Code. All papers must represent a student’s own individual work unless otherwise directed by the instructor. Plagiarism in writing assignments is not acceptable and violates the Honor Code.

Please note that the University has provided me with software that does a very good job in uncovering instances of plagiarism. I have used the software in previous courses and have penalized students upon discovery that they had copied the work of others without proper citation.

**DUES DATES FOR HOMEWORK AND PAPERS**

All homework assignments and reports are due on or before the date and time specified in the Assignments section in the e-Learning system.
COURSE GRADING
The final grade will be determined by an absolute method of grading to allow you to obtain a grade based on your individual performance without having to compete with one other. Under this scheme, it is possible for the whole class to get an A grade or, in the extreme case, for the whole class to get an E grade. I, of course, hope that you will work hard to earn an A.
# Course Content

<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M1. INTRODUCTION</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1 | M1.1 | Course Introduction and Overview  
*What can you learn and use from this course*  
What this course is about. Stories from a non-sustainable world. Important changes taking place in civil infrastructure. What this course covers. Stationarity vs. non-stationarity. Game changing implications of non-stationarity on infrastructure projects. |
| 2 | M1.2 | Course Organization and Content  
*What this course contains and how it will be delivered*  
Course outline and content summary. How the course will be run. Access to the course instructor (me). How to get the most out of this course. How to be successful in this course.  
Stories from the built environment. |
| 3 | M1.3 | The Role and Importance of Infrastructure  
*Infrastructure as an essential contributor to our quality of life*  
| 4 | M1.4 | How Did We Get Here?  
*An Industrial Revolution Retrospective*  
Pre-industrial society: what was it like? A short history of the Industrial Revolution. The agricultural revolution. The first and second Industrial Revolutions. Consequences and warning signs. |
| 5 | M1.5 | The Engineers’ Role in Society’s Well-Being  
*We did good…but at a price*  
Infrastructure and the role of engineers. What do engineers do? The evolution of engineering: from “ingeniators” to professionals. The green revolution. Technical advances have improved our standard of living, but now we are approaching a critical tipping point. Needed: new engineering breakthroughs. |
| 6 | M1.6 | The Engineers’ Dilemma  
*Addressing non-stationarity in a world that thinks stationarity is a given*  
Stakeholder relationships and dynamics. The engineers’ dilemma. Things are about to get more complicated. Transformation “must haves”, outcomes. Actions taken by other groups. |
| **M2. UNDERSTANDING SUSTAINABLE SYSTEMS** | | |
| 7 | M2.1 | Basic Concepts in Sustainability  
*Understanding the language of sustainable engineering design, construction and operation*  
The ecosystem services framework. Types of ecosystem services. Natural resources terminology. Biotic and abiotic resources. Renewable and non-renewable resources. Carrying capacity. Sustainable development, sustainability: other definitions and views. |
| 8 | M2.2 | Are We Sustainable?  
*What does it mean to be sustainable?*  
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 9  | M2.3 | Visualizing Sustainable and Unsustainable Systems  
*The Production-Consumption Model*  
| 10 | M2.4 | Quantifying the Sustainability of Nations  
*The Sustainability Quadrant*  
| 11 | M3.1 | A Brief History of Oil  
*A harbinger of things to come?*  
| 12 | M3.2 | Is Water the Next Oil?  
*Setting the scale, defining the issues*  
| 13 | M3.3 | Non-Renewable Resources  
*Once they're gone, they're gone!*  
Definition of non-renewable resources. Demand, regulatory trends, supply risks, prospects. Civil infrastructure focus: minerals and metals, construction materials, coal, oil and gas. |
| 14 | M3.4 | Critical Materials  
*Materails need, availability, supply risk and prospects for substitution*  
What are critical materials? History: ammonia as a critical material. Technology saves the day! Rare earth elements: Japan vs. China. Assessing the criticality of materials: clean energy technologies, national defense. Critical material strategies. |
| 15 | M3.5 | Ecosystem Services  
*Nature provides them, and they're free!*  
Ecosystem services and relation to well-being. Ecosystem services framework: provisioning, regulating, cultural, supporting. The valuing of ecosystem services. Relationship of ecosystems services, engineering and the built environment. How issues emerge. Warning signs: symptoms of non-sustainability. Introduction to the Millennium Ecosystem Assessment. |
| 16 | M3.6 | The Millennium Ecosystem Assessment  
*The state of ecosystem services*  
Assessing the impacts of non-sustainability. The structure of ecosystem services. The Millennium Ecosystem Assessment findings. The relevance of ecosystem conditions to infrastructure. Deteriorating infrastructure and its consequences. "We’re building 2050 today!" |
| 17 | M3.7 | Climate Change is Simple…And Scary!  
*What happens if we continue with "business as usual"*  
Dave Roberts explains climate change (Video). |

**M4. CLIMATE CHANGE: THE STATE OF PLAY**
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 18 | M4.1 | Climate Regulating Services  
*The greenhouse effect*  
| 19 | M4.2 | History of Climate Science  
*Development of climate science and our understanding of global climate change*  
How our understanding of change evolved, 1820 to the present. Role of carbon dioxide in warming the atmosphere. Milestones in climate science. |
| 20 | M4.3 | Climate Change: What We Know and What We Don’t Know  
*What the climate scientists are telling us*  
Framing the climate change issue. What we know and don’t know about climate change. The development of the climate models. Climate change and its effects. How much is human caused. |
| 21 | M4.4 | The Ecological Impacts of Climate Change  
*Global changes. Regional and local impacts*  
| 22 | M4.5 | Regional Impacts of a Changing Climate  
*Regional and temporal impacts on the U.S*  
| 23 | M4.6 | Climate Change Scenarios  
*Looking at the range of possible futures*  
What are the greenhouse gas (GHG) emission scenarios? Purpose and description. Assumptions. Special Report Emissions Scenarios (SRES) and Representative Concentration Pathway (RCP) scenarios. Relating GHG emission scenarios to outcomes and consequences. |
| 24 | M4.7 | Climate Change Mitigation  
*Taking on the causes of climate change*  
| 25 | M4.8 | Climate Change Adaptation  
*Accommodating changes in environmental operating conditions*  
| 26 | M4.9 | Climate Change Mitigation Through Geoengineering  
*Can technology save the day?*  
What is geoengineering (a.k.a. climate engineering or climate intervention)? What are the points of intervention? What are the possibilities? Geoengineering concepts. The promise and perils of geoengineering (climate engineering). Climate engineering “Plan B.” Evaluation of geoengineering (climate intervention) techniques by the National Research Council. |
| **M5.** | **BECOMING A SUSTAINABLE SOCIETY** | |
| 27 | M5.1 | Creating a Sustainable Society  
*What are the requirements? What are the Issues?*  
The world we live in: levels of societal development. The Tragedy of the Commons: description and examples. Achieving conditions of sustainability. The six degrees of recognition. |
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 28 | M5.2 | **Sustainability in the Developed Nations**  
*Not living within our means...and loving it!*  
The world we live in: characteristics of nations by level of development. Situation for the developed nations. Trends and drivers. Engineering needs. Pathway choices and sustainable design challenges. |
| 29 | M5.3 | **Sustainability in the Developing Nations**  
*Economic growth is what matters*  
| 30 | M5.4 | **Sustainability in the Underdeveloped Nations**  
*Survival!*  
| 31 | M6.1 | **Sustainability Market Drivers**  
*What is industry doing and why is industry doing it?*  
Five emerging trends and forces shaping industry. How industry is responding. The three industry drivers for sustainability: reputation, opportunity and necessity. Examples. |
| 32 | M6.2 | **Creating a Sustainability Strategy**  
*How companies are embracing sustainability and creating shareholder value*  
The virtue matrix: enhancing brand and reputation and creating strategic advantage. The four elements of shareholder value. Responding to the five emerging trends and forces shaping industry. |
| 33 | M6.3 | **The Business Case for Sustainability**  
*Global sustainability mega-forces and their impacts on business*  
Presentation by Bob Willard on how companies can design effective strategies to address sustainability risks while taking advantage of the resulting opportunities. |
| 34 | M6.4 | **Companies Embracing Sustainability**  
*Eight companies for which sustainability is an element of their corporate strategy*  
The Corporate Knights Global 100 most sustainable corporations. How they are ranked. Additional companies and their approach to sustainability: Royal Phillips Electronics (The Netherlands), HCL Technologies Ltd. (India), Ford Motor Company (USA), General Electric (USA), BT plc. (UK), Interface Carpet Corporation (USA), Walmart (USA), New Belgium Brewing (USA). |
| 35 | M6.5 | **New Belgium Brewing Company and Sustainability**  
*A recipe for success or greenwashing on steroids!*  
New Belgium Brewing Company and its commitment to sustainability. Policies and practices. Its culture. Advocacy. Relation to the community. Is this a recipe for success, or is it greenwashing on steroids! Videos of New Belgium news stories, employees and company activities. |
| 36 | M6.6 | **Sustainability in the Public Sector**  
*How are government agencies responding?*  
Public sector roles and responsibilities regarding sustainability. What are the policies and programs? What actions are being taken? |
| 37 | M6.7 | **Structural Change for Improved Sustainable Performance**  
*Raising the playing field and improving competitive advantage*  
Structural change: revisiting the Virtue Matrix. How various industry sectors are setting up programs to improve the industry sector’s sustainable practices. Examples of what some groups are doing and why. |
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 38 | M6.8 | **Corporate Social Responsibility**  
*Doing well by doing good*  
Corporate Social responsibility (CSR) definition and characteristics. Trends and drivers for CSR. Expansion of an organization’s responsibilities. The business case for CSR. Company examples. |
| 39 | M6.9 | **Finding Environmental Justice**  
*Requirements for fair treatment and meaningful involvement for communities*  
What is environmental justice? What are its goals? Timeline of civil rights and environmental justice legislation. Relationship to infrastructure in the built environment. Tools for issue analysis. |
| 40 | M7.1 | **High Performance Buildings**  
*Designing for sustainability because it makes economic sense*  
| 41 | M7.2 | **Factors in High Performance Building Design**  
*Ways to improve the operational performance of buildings*  
The elements of high performance building design. Design approaches. High performance building design examples. |
| 42 | M7.3 | **Sustainable Urban Water Management**  
*Managing water as a system*  
Sustainable urban water resource goals. Dealing with urban water infrastructure as a system. Advanced water and wastewater technologies. |
| 43 | M7.4 | **Making Transportation Systems Effective**  
*Providing efficient mobility and access*  
| 44 | M7.5 | **Addressing the Issues of Sustainable Transportation**  
*Reducing the impacts and increasing resiliency*  
| 45 | M7.6 | **Improving Our Energy Systems**  
*Addressing climate change and energy security*  
| 46 | M7.7 | **Pollution and Waste Management**  
*How do you throw something away when there is no “away”?*  
| 47 | M8.1 | **Tools for Working in a Non-Stationary World**  
*A survey of what tools we have vs. what tools we need*  
What do we mean by tools? Understanding stakeholder dynamics. Need to start by changing the mindsets of project owners and engineers stuck on stationarity. Tools needed vs. tools currently available. Examples. |
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 48 | M8.2 | Environmental Life Cycle Assessments I  
*Four phases and three types*  
| 49 | M8.3 | Environmental Life Cycle Assessments II  
*LCA inventory analysis*  
LCA inventory analysis: process or input-output. Hybrid inventory analysis. Examples. Available LCA software tools. |
| 50 | M8.4 | Social Life Cycle Assessments  
*The emerging art of determining a project’s impact on society*  
| 51 | M8.5 | Calculating Sustainable Return on Investment (S-ROI)  
*A process for valuing triple bottom line impacts*  
Explanation of sustainable return on investment (S-ROI), a triple bottom line valuation framework. A systematic process for calculating benefits and costs of the full range of economic, environmental and social impacts. AIChE videos introduce S-ROI and show how it can be applied. |
| 52 | M8.6 | Sustainable Product Design  
*Applying sustainability principles to product design*  
| 53 | M8.7 | Carbon Footprinting  
*Conducting a GHG inventory using the GHG Protocol*  
| M9.  | ASSESSING AND REPORTING PROGRESS | |
| 54 | M9.1 | Making Progress Toward Sustainability  
*Goals, Objectives and Metrics*  
| 55 | M9.2 | The Sustainable Development Goals for 2030  
*An agenda for the sustainable development era*  
| 56 | M9.3 | Performing Sustainability Audits  
*Five types of audits and their application*  
What is a sustainability audit? Five types of sustainable audits: their purpose and application. |
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 57 | M9.4 | **Sustainability Performance Reporting**  
_The Global Reporting Initiative (GRI) guidelines_  
| 58 | M9.5 | **Controlling and Reducing Greenhouse Gas Emissions**  
_Reporting rules, protocols, cap-and-trade_  
| 59 | M9.6 | **Leadership in Energy and Environmental Design (LEED)**  
_A sustainability rating system for buildings_  
| 60 | M9.7 | **The LEED Certification System**  
_How it works_  
| 61 | M9.8 | **Envision® Sustainable Infrastructure Rating System**  
_Recognizing infrastructure projects for their contribution to sustainability_  
| 62 | M9.9 | **Tools for Calculating Sustainable ROI**  
_Business Case Evaluator and AutoCASE_  
Envision-based, decision support tool for estimating the financial, social and environmental value of infrastructure and building projects. Design alternatives analysis. Data visualization. |

**M10. SUSTAINABILITY AS A DRIVER FOR INNOVATION**

<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 63 | M10.1 | **Innovation and Sustainable Development**  
_Changing operating conditions as a disruptive anomaly_  
What is innovation? Barriers to innovation in sustainable design. The innovator’s dilemma. The eco-innovator’s dilemma. The engineer’s dilemma. Changing operating conditions as a disruptive anomaly. Thomas Kuhn and Bill McKibben. The disruptive innovators. Examples. |
| 64 | M10.2 | **Biomimicry**  
_Innovation inspired by living systems_  
| 65 | M10.3 | **Industrial Ecology and By-Product Synergy**  
_Innovations in industry_  

**M11. NON-STATIONARITY AND PROJECT DELIVERY**

<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
</table>
| 66 | M11.1 | **Engineering for a Non-Stationary World**  
_Delivering infrastructure projects that work under changing operating conditions_  
Infrastructure systems in a program context. Delivering services to a community. The challenges of non-stationarity in the built environment. Managing infrastructure as a system. The sustainable project challenge: designing and delivering infrastructure projects that meet project owner requirements, contribute to sustainable performance, and account for non-stationarity. Current tools available. |
<table>
<thead>
<tr>
<th>#</th>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>M11.2</td>
<td><strong>Sustainable Project Management Overview</strong>&lt;br&gt;<strong>Incorporating sustainability principles and practices into infrastructure projects</strong>&lt;br&gt;What is a project? What are infrastructure projects? Can civil infrastructure projects be sustainable? What is project management? A sustainable project management overview. Doing the project right vs. doing the right project. The life cycle of a civil infrastructure project: six phases. Contrasting traditional vs. &quot;sustainable&quot; projects.</td>
</tr>
<tr>
<td>68</td>
<td>M11.3</td>
<td><strong>The Sustainable Project Management Process, Part 1</strong>&lt;br&gt;<strong>The initial phase of the process: project understanding</strong>&lt;br&gt;Sustainable project management life-cycle review. Using a stage-gate analysis. The process steps for the project understanding phase. Selecting strategies for risk mitigation. Use of the Observational Method for adaptation strategies.</td>
</tr>
<tr>
<td>69</td>
<td>M11.4</td>
<td><strong>The Sustainable Project Management Process, Part 2</strong>&lt;br&gt;<strong>Project completion, operation and maintenance, decommissioning and deconstruction</strong>&lt;br&gt;Completing the project. Operating the project. Avoiding traps and vulnerabilities. Monitoring, pre-planned actions for adaptation. Project decommissioning.</td>
</tr>
<tr>
<td>70</td>
<td>M11.5</td>
<td><strong>Sustainable Project Management: Project Examples</strong>&lt;br&gt;<strong>How project owners are addressing sustainability and non-stationarity</strong>&lt;br&gt;Examples of how cities are addressing the impacts of non-stationarity. Tailored resiliency for lower Manhattan. Barriers to flooding that serve multiple purposes. Resist, delay, store and discharge: a strategy for the city of Hoboken, New Jersey. The Prairie Waters Project: finding a new sustainable water source for the City of Aurora, Colorado.</td>
</tr>
<tr>
<td><strong>M12. RESILIENT, SUSTAINABLE CITIES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>M12.1</td>
<td><strong>Creating Sustainable Cities</strong>&lt;br&gt;<strong>The city as an efficient form of human habitat</strong>&lt;br&gt;What is a city? Increasing global urbanization. Importance of cities. Elements of a sustainable city.</td>
</tr>
<tr>
<td>72</td>
<td>M12.2</td>
<td><strong>Becoming a Sustainable City</strong>&lt;br&gt;<strong>The four challenges</strong>&lt;br&gt;Four challenges in creating sustainable cities: technical, financial, organizational and public policy.</td>
</tr>
<tr>
<td>73</td>
<td>M12.3</td>
<td><strong>Green City Development</strong>&lt;br&gt;<strong>Sectorial strategies for sustainable growth and development</strong>&lt;br&gt;New opportunities for cities created by a shift to sustainability. Sectorial strategies: How cities are taking advantage of these opportunities. Types of sectorial strategies. City response to climate change. Ranking cities based on sustainability criteria.</td>
</tr>
<tr>
<td><strong>M13. PROSPECTS FOR A SUSTAINABLE FUTURE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>M13.1</td>
<td><strong>Becoming a Sustainable Society</strong>&lt;br&gt;<strong>A business-focused roadmap to 2050</strong>&lt;br&gt;A business as usual outlook to 2050. WBCSD’s Vision 2050: directions to a sustainable world. The pathway to 2050: nine elements. “Must haves” by 2020. Moving from vision to action. Risks to achieving vision 2050.</td>
</tr>
<tr>
<td><strong>M14. COURSE WRAP-UP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>M14.1</td>
<td><strong>Course Wrap up</strong>&lt;br&gt;<strong>Brief summary of the course</strong>&lt;br&gt;Here’s what we covered in the course. Here’s what we didn’t cover. The B.H.A.G. revisited. Best 10 books on sustainability (my nominations). Good bye and good luck!</td>
</tr>
</tbody>
</table>

**END OF THE COURSE**