ENRGYENV 491 – Modeling and Analysis for Environmental Sustainability
Fuqua School of Business

In 1987, the World Commission in the Environment and Development, also known as the "Brundtland Commission," defined sustainable development as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Although there are many ways in which this basic statement has been elaborated, it remains the fundamental concept underlying the entire sustainability movement among firms, governments, NGOs, and individuals today.

Many firms are beginning to look for ways to do business in a more sustainable way, whether that means reducing their use of fossil fuels for energy, extracting resources in a way that does not threaten the future supply of those resources, or finding ways to manage their waste streams to reduce pollution and even to capture value from what is currently discarded. Governments are struggling with carbon policies, and firms are beginning to request regulation in an effort to resolve the current uncertainty about what those regulations will look like. NGOs are involved in sustainability efforts around the globe, partnering with governments and firms, and in many cases providing vehicles for stakeholders to get involved in the push toward sustainable economic development.

In this course, we will look at tools that businesses can use to measure, evaluate, and manage their sustainability. The course has three parts, each one corresponding to about two weeks in our six-week schedule. We learn how to calculate a greenhouse gas inventory and the tools that are needed to do this. We will find out that companies are facing new risks, and we will learn how to evaluate those risks. Finally, we will see how managers can use the tools they have to develop and evaluate different alternatives – including the use of emissions allowances and offsets – as they decide how to incorporate sustainability in the firm's strategy.

Class times: Class meets Monday-Thursday 4:00-6:15
Location: The Connally Classroom at Fuqua. Non-Fuqua students: You can download a map at http://www.fuqua.duke.edu/documents/programs/campus_map.pdf

Instructor: Bob Clemen
Office: Academic Center W319
Phone: 660-8005
E-mail: clemen@duke.edu

Office hours: Most afternoons, except Wednesday. Please call first if. If you can't call, drop by anyway. Usually I can give you the time you need, when you need it.

Contacting me: Phone calls and emails both work well. Please use email for straightforward questions that only need a short (a sentence or two) answer. Please call or come to my office if we will need to have a conversation. If you've sent me an email asking a question but haven't heard back for a while, please follow up with a phone call.

Where should you call? Try the office first (919-660-8005) and then my cell phone (919-451-4073). If you leave a message, please include a number where I can reach you. I work at home a lot, and I don't mind you calling me on my cell there. During the day, evenings, and weekends are all OK. Please don't call before 9:00AM or after 9:00PM.

About email: I will do my best to stay current with email. However, there are two limitations. First, my time is limited during the afternoons when I am teaching. Second, my last email check in the evening may be around 9:30 or 10:00. After 9:00 PM I may only answer quick questions.

Course web site: http://faculty.fuqua.duke.edu/courses/decision491sustainability/
You will find what you need, like this syllabus, assignments, links to our electronic library reserves, and more.

Grades: Your grade will be determined by your performance on three graded cases (completed in teams), individual assignments, a term project, and participation:

Cases	30%
Individual assignments	30%
Term project	30%
Participation	10%

Some details about the assignments:

- **Individual assignments.** You will complete four individual assignments. These will require you to apply to tools we have studied, and you might have to locate and use information on the Internet in order to complete the calculations or answer the questions. You may hand in hard copy or send them to me by email. Individual assignments will be due by 5:00 PM on Friday.
- **Team assignments.** You will have two team assignments to complete. These are case studies and will require you to assemble a report showing your analysis, arguments, insights, and conclusions. I will provide details about my expectations with each assignment. The teams will consist of two people, and I will assign the teams.
- **Term project.** The term project will get you thinking about and applying the tools we study to a specific company. Please see details below.
- **Participation**. I expect everyone to contribute to our class discussions throughout the term. I do intend to cold-call a few people each day at random to answer questions about the readings.

Readings:

- The **coursepack** contains the cases we will cover; plan to purchase a copy.
- Our **electronic reserves** site (http://library.fuqua.duke.edu/reserves.htm, accessible through the course website) will have articles and book chapters.
- Our **course website** (http://faculty.fuqua.duke.edu/courses/decision491sustainability/) has links to many additional resources.

Expectations: I've changed this course radically based on student feedback last year, so there are two things that are critical for you to understand:

- **My expectations:** It is very important that you understand what I value most in my students: initiative and thinking that is creative, independent, and critical. This is true in all of my courses, but especially here. There are many directions one can take to study tools for environmental sustainability. Although I have put together a course that I believe makes good sense, you are encouraged to take initiative in learning about other

aspects of sustainability management and bringing what you learn to my attention and to that of the class.

- **Your expectations:** Because many of the assignments and lectures are new, please do not expect everything to be perfect. I will do my best to provide you with everything you need – assignments, readings, exercises, Powerpoint slides – but please realize that many will be first drafts, and they may be rough. By the same token, I will be more than willing to consider refinements to virtually any aspect of the course as we make our way through the term.

Fuqua Honor Code: All aspects of the Fuqua Honor Code apply. Perhaps most important for this class is that all work you hand in must be your own, or it must be properly attributed. It is a serious honor code violation to "copy and paste" material from other sources into your own document without indicating the source. (This doesn't mean you cannot quote material you get from articles, books, or the web. You just have to indicate the source.)

Read the full Fuqua Honor Code at http://www.fuqua.duke.edu/about/honorcode/index.html

A few additional notes:

- **Computers in class:** Laptops are welcome in class. In particular, we may have many opportunities to refine and re-run computer models or to locate information online.
- **Missing classes:** Please let me know in advance if you have to miss class.
- **Starting on time:** I will start on time at the beginning of class and after the break. If you do come in late, I will try to quell a demonic urge to cold-call you before you sit down. In the past I've had some limited success in doing that. ;-)

IMPORTANT ACTION ITEMS

1. Do the preassignment. See below for details.
2. Read through the description of the term project below, and start thinking about companies you might like to analyze.
3. Read through the course schedule to get an idea of what we will cover.
4. Familiarize yourself with the course website and our electronic reserves (links above).
5. Please bring any questions you have to the first day of class.

Course Schedule

Session - date	Topics
1 – Mar 16	Introduction and course overview. Introduction to greenhouse gas inventory
2 – Mar 19	Corporate GHG inventories. Guest speaker: Tavey Capps. Duke Sustainability Coordinator. GHG inventory at Duke. *Exercise 1 on GHG inventories due Friday, March 20*
3 – Mar 23	Life cycle assessment (LCA), a brief introduction
4 – Mar 26	Toxic substances and pollution. Guest speaker: Mike Colarossi, Akzo Nobel *Exercise 2 on LCA due Friday, March 27*
5 – Mar 30	Eco-labels and certification programs. Introduction to risk assessment for sustainability
6 – Apr 2	Guest speaker: Dan Vermeer. Drowning in risk: Water in Coca Cola's value chain.
7 – Apr 6	*Team assignment #1 due: Walmart Sustainability Strategy* Guest speaker: Michelle Harvey, Environmental Defense Fund
8 – Apr 9	Guest speaker: Mike Colarossi, Akzo Nobel Risk assessment examples: Climate risk at Yucca Mountain. *Exercise 3 on risk assessment due Friday, April 10*
9 – Apr 13	Finishing Risk analysis: The Duke Coal Pile Evaluation and decision making: abatement curves, wedge analysis, and economics
10 – Apr 16	More on abatement curves. Optimization tools for environmental sustainability *Exercise 1 on economic analysis and decision making due Friday, April 17*
11 – Apr 20	Real options and risk analysis. Introduction to offsets and carbon trading.
12 – Apr 23	*Team assignment #2 due: c-Energy's Red Hill Plant* Earth day! Case discussion and course wrap-up
Apr 29, 5:00 PM	Deadline for submitting term projects

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Duke University
Spring Term 2, 2009

Term Project: Company Sustainability Analysis

Select a company that has produced a recent sustainability report (or for which you can get or reasonably infer information about GHG emissions and other footprint issues). With a partner, you will analyze this company using the tools that we study in the course. Following the general pattern of the course, your report should have three parts:

- Company footprint assessment. What are the main footprint issues that this company faces? Does their sustainability report adequately represent these issues?
- Sustainability risk assessment. What are the primary risks that the company faces? Think about how you might use one or more of the risk-assessment tools we have studied to characterize the company's risks.
- Analysis of alternatives. What do you see as the company's alternatives? How can they address their risks in an economically sound way?

Deliverables:

- Milestone reports. These are one page maximum, bullet points plus brief explanation of how you have or intend to address this part of the project:
    - March 27. Company footprint assessment.
    - April 10. Sustainability risk assessment.
    - April 23. Analysis of alternatives.

- April 29. Comprehensive write-up. You should have a main text that summarizes your findings (10-20 pages, double-spaced, including graphics as needed), supplemented by relevant supporting documents included as appendices.

See the Global Reporting Initiative website for a list of companies that have filed sustainability reports. http://www.globalreporting.org/GRIReports/GRIReportsList/

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Preassignment

1. Readings:
   - Read the attached article from Harvard Business Review, "Forethought: Business Climate/Climate Business. This article covers at a very high level most of the climate-related sustainability issues that companies face.
   - Read Chapters 1-4 of the Greenhouse Gas Protocol (attached). This will lead you through the initial steps of performing a GHG inventory, our first main topic in the course.
   - Read the attached article "Corporate Greenhouse Gas Emissions Management: The State of Play." This gives an idea of what corporations – primarily in Europe – are doing about GHG emission measurement and management.
   - Optional: Read the Intergovernmental Panel on Climate Change (IPCC) Synthesis report "Summary for Policymakers." This is an overview of the entire 2007 IPCC report. You have probably seen bits and pieces of this report. It is worthwhile reading the whole thing. Website: http://www.ipcc.ch/ipccreports/ar4-syr.htm. Click on "SPM."

2. You have probably calculated your GHG footprint, but I'd like to have you do so again. The reason should become obvious! Calculate your personal GHG emissions using at least four different calculators. Try to find calculators that include roughly the same items. You should get different results from different calculators. Why? Which one(s) do you have the most faith in?

   Be ready to report your results in our first class.

   Here are several websites, and you can easily find more online:
   - EPA: www.epa.gov/climatechange/emissions/ind_calculator.html
   - EPA's Excel version, particularly useful because it explains exactly what it is calculating: www.epa.gov/climatechange/emissions/downloads/GHGCalculator_11-06.xls).
   - WRI/SafeClimate: http://www.safeclimate.net/calculator/
   - ICLEI: http://www3.iclei.org/co2/co2calc.htm
   - Climate Trust: http://www.carboncounter.org/offset-your-emissions/personal-calculator.aspx
   - AOL: http://reference.aol.com/planet-earth/global-warming/calculator
   - Nature Conservancy: http://www.nature.org/initiatives/climatechange/calculator/?src=f1
   - Terrapass: http://www.terrapass.com/carbon-footprint-calculator/#road
   - An Inconvenient Truth: http://www.climatecrisis.net/takeaction/carboncalculator/
   - Carbonify.com: http://www.carbonify.com/carbon-calculator.htm

3. The following websites will be very useful for us during the term. Please visit them and become familiar with them:
   - Environmental Protection Agency (EPA): http://www.epa.gov/
   - Energy Information Administration (EIA): http://www.eia.doe.gov/
   - GHG Protocol: http://www.ghgprotocol.org/
   - Global Reporting Initiative (GRI): http://www.globalreporting.org/Home

4. Complete the problems on the next page. You may have solved problems like this before (in which case these should be easy!). These will not be graded, and I will not collect them. The reason I am asking you to solve these problems is so that you will be able to perform basic calculations with emission factors and units of energy. A solution will be available after our first class.

Decision Tools for Environmental Sustainability

DECISION 491

Session 1 >

Topics:

- Introduction and course overview
- Introduction to greenhouse gas inventories

Learning Objectives:

- Understand the overall structure of the GHG Protocol process for performing a GHG inventory
- Understand how to set organizational and operational boundaries
- Understand the concept of scope, and the kinds of emissions that are included in Scopes 1, 2, and 3
- Be able to perform basic GHG emission calculations
- Know the locations of and how to use online GHG calculation tools for organizations

Preparation: See **preassignment** and our **electronic reserves**

Course Materials:

- **Exercise 1: Zany Zoo Pets (pdf)**. Due Friday, March 20, 5:00 PM
- **ZanyZooPets.xls**
- **Session 1 slides**
- **Solution to preassignment problems**
- **Solution to Zany Zoo**

Links:

- Personal GHG Calculators. See the preassignment. Here are several websites, and you can easily find more online:
  - **EPA** (You can also download **EPA's Excel version**).
  - **WRI/SafeClimate**
  - **ICLEI**
  - **Climate Trust**
  - **AOL**
  - **Nature Conservancy**
  - **Terrapass**
  - **An Inconvenient Truth**
  - **Carbonify.com**
- At the **DANTES** website, you can read about a variety of tools for environmental sustainability. The website also includes links to online software.
- The following websites will be very useful for us during the term. Please visit them and become familiar with them:
  - Environmental Protection Agency (EPA): **http://www.epa.gov/**.
    Note especially EPA's **eGRID** section.
  - Energy Information Administration (EIA): **http://www.eia.doe.gov/**
  - GHG Protocol: **http://www.ghgprotocol.org/**
  - Global Reporting Initiative (GRI): **http://www.globalreporting.org/Home**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 2 >

Topics:

- Organizational Greenhouse Gas Inventory
- Duke University GHG Inventory
  - Guest Speaker: Tavey Capps, Duke Sustainability Coordinator
- SAS for Sustainability Management
  - Keith Renison, SAS
- Cisco GHG inventory and use of SAS tool
  - Rob Rolfsen, Cisco Systems, Director of Sustainable Development

Learning Objectives:

- Understand the complexity of performing a GHG inventory
- Understand how Duke's purpose and organizational system drove the inventory process
- Understand how GHG inventory information can be organized for decision support
  - Examples from SAS system
  - Experience at Cisco

Preparation:

- Read *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Chapters 5-9
- Read Sullivan et al., "Corporate Greenhouse Gas Emissions Management: The State of Play"
- Visit the **ACUPCC website** to understand what President Brodhead committed Duke to do.

Course Materials:

- Reminder: **Exercise 1: Zany Zoo Pets**. Due Friday, March 20, 5:00 PM
- **ZanyZooPets.xls**
- **Solution to Zany Zoo**
- Session 2 slides
  - **Tavey Capps' slides -- Duke GHG Inventory**
  - **Keith Renison's slides**
  - **Bob's slides**
- **Recording of Session 2**

Links:

- **Duke's GHG inventory (Excel file)**
- **Clean Air, Cool Planet**
- **SAS for sustainability Management**
- **Cisco's 2008 Sustainability Report**
- **Carbon Disclosure Project (CDP)** A large database of GHG inventories. A company completes a standard questionnaire about its GHG inventory process, so you get a deeper picture into the company's activities beyond just seeing the total emissions.
  - Example: **DuPont CDP response 2008** and **DuPont total emissions**
- Some company examples:
  - **Walmart (Excel file)**
  - **General Motors**
  - **World Resources Institute**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 3 >

Topics:

- Introduction to Life Cycle Assessment: Basic Concepts and Procedures
- Alpha Motors and the EPS System

Learning Objectives:

- Understand basic concepts and procedures of Life Cycle Assessment
- Learn the importance of and how to establish system boundaries for LCA
- Learn how different LCA systems weight different environmental aspects (GHG, toxic emissions, water use, etc.)
- Be able to perform simple LCA calculations
- Appreciate the complexity of LCA
- Understand the difference between conventional (bottom-up) and Economic Input-Output (top-down) LCA approaches

Preparation:

- Read (**E-reserves**)
  - Svoboda, S. "Note on Life Cycle Analysis"
  - Graedel & Allenby, " The LCA Impact and Interpretation Stages"
- Case preparation
  - **Alpha Motors** (in coursepack)
  - **Alpha Motors spreadsheet**
  - Questions to prepare for class discussion (nothing to hand in or submit):
    - Rank the materials according to cost. Compare the contribution of raw material, manufacturing and disposal costs to the total cost.
    - Compare the materials with respect to overall environmental impact and for each process (production, use, recycle, landfill, incinerate) of the life cycle. What insights do you get by considering the processes separately?
    - Explain how the EPS system converts environmental impact to a dollar equivalent. What are the advantages and disadvantages of this approach?
    - The EPS calculations are detailed, but we can make sense of them. For example, consider Row 240 in the spreadsheet. This row shows the CO2 ELU/kg of material for each actvity. (Material is identified in Rows 209 and 259.) Use these numbers, along with the kg of material used (C11:E11) to calculate the total CO2 ELUs/hood for each material.
    - Considering both manufacturing cost and the environmental impact, what material should Alpha select? Do you think that Mike should just sum up the manufacturing cost and the environmental impact in order to select the best alternative?

Course Materials:

- **Exercise 2: Method**. Due Friday, March 27, 5:00 PM
- **IFEU LCA report**
- **Method.xls**
- **Session 3 slides**
- **Recording of Session 3**
- **Method solution**

Links:

- For fun: **The Story of Stuff** (video, 20 minutes)
- **A recent LCA on diapers** - concluding that there really isn't much difference between

home-laundered cloth, commercial service, and disposable. Moreover, it concludes that the overall impact of diapering a child for 2.5 years is about the same as driving a car between 1300 and 2200 miles.

- See our **E-reserves** for articles about LCA for grocery bags, a wind turbine, an office chair, beer, biofuels, and an office building. Most of these are from the International Journal of Life Cycle Assessnment. Read/scan at least one of these articles to get an idea of what a real life-cycle assessment is like.

Decision Tools for Environmental Sustainability

DECISION 491

< Session 4 >

Topics:

- Finish LCA
- Toxic releases and pollution
- The Toxic Release Inventory

Learning Objectives:

- How toxic releases are regulated
- what is the TRI and why it matters
- Are companies that are more environmentally conscious also more profitable? What are the issues in answering this question?
- Understand the life cycle of recycling
- Examples of corporate waste-reduction programs

Preparation:

- Read (**E-reserves**)
  - King, A., and Lenox, L. "Exploring the Locus of Profitable Pollution Reduction." Management Science (2002) 48(2): 289-299.
  - "High Tech Trash" and "Recycling: The Big Picture." National Geographic, January, 2008, 64-87.
  - Bryson, Bill. "Getting the Lead Out." A Short History of Nearly Everything, New York: Broadway Books (2003). Chapter 10: pp 149-160.
- Go to **http://www.epa.gov/tri/** and read about the Toxic Release Inventory program.

Reminder:

- Term project Milestone #1 is due on Friday, March 27. 5:00 PM. Company footprint assessment. What are the main footprint issues that this company faces? Does their sustainability report adequately represent these issues?

Course Materials:

- Reminder: **Exercise 2: Method**. Due Friday, March 27, 5:00 PM
- **IFEU LCA report**
- **Method.xls**
- **Session 4 slides**
- **Recording of Session 4**
- **Method solution**

Links:

- **EIO-LCA**. We will take a look at this "top-down" approach to LCA in our next class.
- Professional LCA software. Both have trial versions you can download:
  - **SimaPro**
  - **Gabi**
- **MapEcos**. An interesting look at the TRI database.

Decision Tools for Environmental Sustainability

DECISION 491

< Session 5 >

Topics:

- Eco-labels and certification programs
- Ceago Vinegarden case discussion
- Introduction to risk assessment for sustainability

Learning Objectives:

- Learn how eco-labels and certification programs can help a company differentiate its products.
- Understand the complexity of the eco-label "industry":
  - Number and types of eco-labels.
  - How eco-labels do (and do not) communicate messages to consumers.
- Be able to evaluate and choose an eco-labels for a particular business or product.
- Be able to identify key sustainability risk areas for a company.

Preparation:

- Read the Ceago Vinegarden case. Discussion questions:
  - What are the costs and benefits that Jim Fetzer should consider in deciding whether to go for either organic or biodynamic certification?
  - How would you compare the organic and biodynamic eco-labeling programs? What are the advantages and disadvantages of each?
  - How could you estimate the dollar value of an eco-label?
  - Fetzer is considering eco-labeling as a way to differentiate his products in a crowded market. What other approaches might he consider? Why?
  - In general, what conditions do you think is required for an eco-label to do a good job of
    - Communicating its message to consumers?
    - Differentiating a product or brand?
  - Do you think there is a need for an organization to "certify" the labels? (That is, assure that an eco-label adheres to a set of standards and principles?)
- Choose an eco-label and look up information about it on the web. Be ready to share what you learned with the class -- for example, what it certifies, whether it "competes" with other labels, how it relates to other labels you know of in the same product space, pros and cons, ...
- Read "Competitive Advantage on a Warming Planet" by Lash and Wellington. On our **E-Reserves** website. This article does a nice job of summarizing the new risks companies are facing. Can you think of any climate-change or sustainability risks that the authors do not mention?

Course Materials:

- **Team Assignment 1: Wal-Mart's Sustainability Strategy**. Due Sunday, April 5, 10:00 PM.
- **Bob's Session 5 slides**
- **Radhika Palany's slides on Ecolabels**. Radhika has requested that I make these available to you by request only. **Click here** to send me an email requesting a copy.

Links:

- **Ceago Vinegarden**
- Consumer Reports **Greener Choices Eco-Label Center**
- **EU Eco-Label - The Flower**
- USDA Organic links:
  - **National Organic Program**
  - **Alternative Farming systems Information Center**
- **Demeter, USA**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 6 >

Topics:

- Coca Cola: Understanding and mitigating water risks
  Guest Speaker: Dan Vermeer, former Sustainability Officer at Coca Cola
- Risk assessment and Enterprise Risk Management

Learning Objectives:

- Learn how a major company examined its value chain to identify risks and then develop and implement a strategy to mitigate them.
- Understand the elements of risk assessment.
- Be able to identify and quantify important corporate risks.

Preparation:

- Read Chapter 7 from "The Necessary Revolution" by Peter Senge **(E-Reserves)**
- Read "Enterprise Risk Management at Hydro One" in your coursepack. Discussion questions:
  - What are the steps in Hydro One's ERM process?
  - Exhibit 7 shows the history of Hydro One's risk profiles up to July, 2006. Based on information in Exhibits 8 and 9, and Laura Formusa's "interview" on page 8 of the case, add a column to Exhibit 7 for 2006 Q4.
  - Do you think Hydro One's ERM system does an adequate job of characterizing the risks that the company faces? What are the advantages and disadvantages of the system?
  - When the senior management team ranks investment proposals by "bang for the buck" (page 7), what exactly does that mean in terms of the magnitude and probability scales on the risk map (Exhibit 6)?

Course Materials:

- **Team Assignment 1**: **Wal-Mart's Sustainability Strategy**. Due Sunday, April 5, 10:00 PM.
- Bob's **Session 6 slides**
- **Dan Vermeer's presentation**

Links:

- Coca Cola's **Sustainability web page**
- **Hydro One**
- Some links on Enterprise risk Management:
  - **http://www.coso.org/-ERM.htm**
  - **http://www.casact.org/research/erm/overview.pdf**
  - **http://www.emrisk.com/**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 7 >

Topics:

- Case debrief: Wal-Mart Sustainability Strategy
- Guest Speaker: Michelle Harvey, Fuqua 89 (WEMBA), EDF, Bentonville, AR

Learning Objectives:

- Understand Wal-Mart's sustainability strategy:
  - How the strategy affects Wal-Mart operations up and down the value chain
  - The implications for Wal-Mart suppliers and their interactions with the company
  - The tools that Wal-Mart is using to develop and mplement the strategy

Preparation:

- Team Assignment 1: **Wal-Mart's Sustainability Strategy**. Due Sunday, April 5, 10:00 PM.

Course Materials:

- **Exercise 3: Tempes Corporation**. Due Friday, April 10, 5:00 PM
- **Tempes.xls**
- **Tempes Solution**

Links:

- Wal-Mart's **Sustainability web page**
- **GreenBiz.com, 2/2/2009**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 8 >

Topics:

- Guest Speaker: Michael Colarossi, Fuqua 09 (GEMBA), AkzoNobel Industrial Finishes. AkzoNobel and Environmental Sustainability.
- Risk Assessment for sustainability: Scenarios, Sensitivity, and Subjective Probability

Learning Objectives:

- Learn about AzkoNobel's sustainability program. How does an industrial chemical company measure and manage its footprint?
- Learn how to use sensitivity analysis tools in Excel: Goal Seek, Scenario Manager, and SensIt.
- Learn how expert judgment and subjective probability assessment are used to forecast long-term trends.

Preparation:

- Visit **AkzoNobel's website**. What do you think are the company's greatest sustainability challenges?
- Read at least one of these:
  - **"Expert assessments of future photovoltaic technologies,"** by Curtright, Morgan, and Keith. A recent study using expert judgments.
  - **"Future climate at Yucca Mountain, Nevada proposed high-level radioactive waste repository,"** by Miklas et al. This is an overview of the Yucca Mountain climate risk assessment project, explaining how we elicited probabilistic forecasts from expert climatologists, looking 10,000 years into the future.
  - **"Improving the way we think about projecting future energy use and emissions of carbon dioxide,"** by Granger Morgan and David Keith. A lovely (if long) essay that attempts to bridge the divide between scenario analysis and subjective probability.
- As time and inclination allow, watch the flash videos listed below.

Reminder:

- Term project Milestone #2 is due on Friday, April 10. 5:00 PM. Company footprint assessment. Sustainability risk assessment. What are the primary risks that the company faces? Think about how you might use one or more of the risk-assessment tools we have studied to characterize the company's risks.

Course Materials:

- Reminder: **Exercise 3: Tempes Corporation**. Due Friday, April 10, 5:00 PM
- **Tempes.xls**
- **Tempes Solution**
- **Session 8 slides**
- **Michael Colarossi's slides on AkzoNobel**
- Flash videos. I created these for my GEMBA Decision Models course, so they are not sustainability-oriented. But they are useful for learning the tools:
  - **Scenario Manager and Goal Seek** in Excel
  - **Using SensIt**
  - Download SensIt Excel add-in: **sens142a.xla**. (Save to your desktop.)
  - **finance.xls** -- example spreadsheet used in the videos

Links:

- **AkzoNobel website**
- Check out the **DANTES** website. AkzoNobel was one of the partners in this project. A very useful website

if you are looking for a catalog and short descriptions of sustainability tools. Includes links to online software.

- **Expert interview** form for Future Photovoltaics study.

Decision Tools for Environmental Sustainability

DECISION 491

< Session 9 >

Topics:

- Environmental risk analysis using Monte Carlo simulation
- Optimization, abatement curves, and wedge analysis

Learning Objectives:

- Understand how Monte Carlo simulation and tools like Crystal Ball are used to understand corporate enivironmental risks
- Understand the principles and shortcomings of abatement curves and wedge analysis
- Learn principles of optimization, a more general framework for making sustainability choices

Preparation:

- Duke Coal Pile (in coursepack). Download **Coal_Pile.xlsx**, which contains the basic model. Do what you can with this problem. If you have taken or are taking Decision Models, it should be relatively straightforward. If you have not, you are welcome to team up with someone who knows how to use Crystal Ball. And I've provided some Flash videos below that can help.
- Go to the Marion Koshland Science Museum, and try out the **American CO2 Emissions Calculator** online activity. What do you learn about individual activities versus policy? (The **Marion Koshland Science Museum** is associated with the National Academy of Sciences. Their exhibits come from recent NAS studies.)
- " **Pathways to a Low-Carbon Economy** " McKinsey & Company 2009. McKinsey came up with the idea of an "Abatement Curve." It's a great way to lay out possibilities for reducing CO2, ordered in terms of incremental cost.
- Socolow, R., and Pacala, S. " **A Plan to Keep Carbon in Check** ," Scientific American (September 2006) pp 50-57. A key article on the idea of a "wedge analysis."
- **USEPA: A Wedge Analysis of the US Transportation Sector**. A short example of a wedge analysis.

Course Materials:

- **Coal_Pile.xlsx**
- **Exercise 4: St. Charles Medical Center**. Due Friday, April 17, 5:00 PM
- **StCharles.xls**
- **St Charles solution**
- **Foothills and Dev-Energy optimization examples**
- **Session 9 slides**
- More Flash videos for learning Crystal Ball and Solver:
  - Finding Tools in Excel 2007
    - **Finding Tools video**
    - **Finding Tools pdf**
  - Crystal Ball Videos:
    - **Part 1. Creating and Testing Models**
    - **Part 2. Running a Model and Evaluating Results**
    - **Part 3. Using Crystal Ball to Make Decisions**
    - **Tax Saver Benefit problem**
  - Solver Videos:
    - **Part 1. Solver Basics**
    - **Part 2. Solver's Sensitivity Report**
    - **Part 3. Understanding Reduced Costs**

- **Part 4. Nonlinear Optimization**
- **Ebel Mine.xls**

Links:

- A Flash presentation explaning **wedge analysis**
- Critique of **wedge analysis**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 10 >

Topics:

- More on Optimization: Multiple objectives, constraints, and decision making for sustainability
- ROE: Return on Everything

Learning Objectives:

- Understand how to model multiple objectives for optimization
- Understand how constraints and shadow prices can guide decision making

Preparation:

- No reading for today.
- Review the Foothills and Dev-Energy examples (below)
- Read the St Charles Medical Center case and assignment. If you have questions about how to do something, feel free to ask in class. I won't give away the answer, but I want to be sure you have to tools to do the assignment.
- Watch the Solver and R&D portfolios below as needed.

Course Materials:

- Reminder: **Exercise 4: St. Charles Medical Center**. Due Friday, April 17, 5:00 PM
- **StCharles.xls**
- **St Charles solution**
- **Session 10 slides**
- **Foothills and Dev-Energy optimization examples.xls**
- **Nelson-Amstore problem**
- **Nelson-Amstore.xls**
- More Flash videos, this time for learning about portfolio optimization:
  - **R&D portfolio part 1**
  - **R&D Portfolio part 2**
  - If needed, don't forget the Solver Videos listed previously under Session 9:
    - **Part 1. Solver Basics**
    - **Part 2. Solver's Sensitivity Report**
    - **Part 3. Understanding Reduced Costs**
    - **Part 4. Nonlinear Optimization**
    - **Ebel Mine.xls**
- **Abatement curves in Excel.xlsx**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 11 >

Topics:

- Sustainability, the long view, and the importance of real options
- Offsets, emission allowances, and markets

Learning Objectives:

- Understand the nature of real options and downstream decisions, and their application to sustainability challenges.
- Understand how emission markets work, the different kinds of offsets available, and how allowances and offsets can be a part of a company's climate-change strategy.

Preparation:

- Read the UBS and Climate Change case in your coursepack. Two questions to think about as you prepare for class discussion:
  - Which of the four options do you think Suter should adopt?
  - If UBS decides to adopt any one of the four options, do you recommend reducing the company's own energy consumption or should UBS buy carbon offsets? If you prefer the latter, is your recommendation to invest in CERs, ERUs or VERs?
- Read "The influence of climate change regulation on corporate responses: The case of emission trading," by Kolk ad Pinske, in our E-Reserves.

Course Materials:

- **Team Assignment 2: c-Energy's Red Hill Plant**. Due Thursday, April 23, 1:00 PM.
- **RedHill.xls**
- **Session 11 slides**
- **EScore-eStore Excel file**
- **Ecosecurities LULUCF Guidebook**
- **Optional: Term project milestone #3 due Friday, April 24, 5:00 PM.** If you send me something, I will take a look and provide feedback.

Links:

- **UBS's Corporate Responsibility web page**
- **United Nations Framework Convention on Climate Change** (UNFCCC)
  - **Kyoto Protocol**

Decision Tools for Environmental Sustainability

DECISION 491

< Session 12 >

Topics:

- c-Energy's Red Hill Plant case debrief
- Course wrap-up and a perspective on corporate sustainability

Learning Objectives:

- Understand how optimization and simulation combine to address corporate environmental decisions.
- Understand the interplay between environmental policy and corporate strategy.
- Understand why "corporate activism" matters.

Preparation:

- Prepare the Red Hill Plant case. We will have a visitor in class: the author of the case, Professor Anton Ovchinnikov from Darden. Bring your questions!

Course Materials:

- **Reminder: Team Assignment 2: c-Energy's Red Hill Plant**. Due Thursday, April 23, 1:00 PM.
- **RedHill.xls**
- **Red Hill solution**
- Session 12 slides
- **Optional: Term project milestone #3 due Friday, April 24, 5:00 PM.** If you send me something, I will take a look and provide feedback.

Links:

- **"Economics of Pollution Trading for SO2 and NOx,"** Burtraw et al. This appears to be the most comprehensive review of the SO2 and NOx trading programs.
- **EPA Factsheet on the SO2 market**
- **"US Carbon Market Design: Regulating Emission Allowances as Financial Instruments"** Working paper from the Nicholas Institute for Environmental Policy Solutions
- New York Times: **"Use Energy, Get Rich, and Save the Planet."** An interesting perspective on sustainability
- I do not know if there is a relationship with our case, but this project is very interesting: **Red Hills Ecoplex**