Introduction to Sustainability for Engineers

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Goal of this lecture

Why should you care about sustainability?

What does sustainability mean?

How will it affect me as an engineer?
End of Lecture Exercise

• A green building is being envisioned on UT main campus.
  – People will use the restrooms
  – There will be labs
  – There will be rainwater on site
  – We need water and sanitation on site

As an engineer, which questions would you ask towards sustainable solutions to meet human needs while working with nature?

• NOTE: Don’t work against nature
<table>
<thead>
<tr>
<th>Industrial revolution based approach</th>
<th>Sustainability revolution based approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump to business as usual</td>
<td>Analyze the process. What synergies can be created? Biomimicry?</td>
</tr>
<tr>
<td>Collect and treat wastewater</td>
<td>Find a solution to deal with these processes that will improve social, economic, and environmental conditions on site and elsewhere</td>
</tr>
<tr>
<td>Collect and remove storm water from site</td>
<td></td>
</tr>
</tbody>
</table>
Humans’ Impact on Earth: A Disaster is Brewing

- Pollution
- Climate change
- Water supplies
Global Warming

• What are the implications?
### Projected impact of climate change

**0.6° Celsius (1.1°F).**

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C</td>
<td>-</td>
</tr>
<tr>
<td>1°C</td>
<td>Water scarcity, extreme climate events, invasive species</td>
</tr>
<tr>
<td>2°C</td>
<td>Possible rising yields in some high latitude regions</td>
</tr>
<tr>
<td>3°C</td>
<td>Falling crop yields in many areas, particularly developing regions</td>
</tr>
<tr>
<td>4°C</td>
<td>Falling yields in many developed regions</td>
</tr>
<tr>
<td>5°C</td>
<td>Sea level rise threatens major cities</td>
</tr>
<tr>
<td>6°C</td>
<td>Rising number of species face extinction</td>
</tr>
</tbody>
</table>

### Global temperature change (relative to pre-industrial)

- 4°C: Falling crop yields in many areas, particularly developing regions
- 5°C: Falling yields in many developed regions
- 6°C: Sea level rise threatens major cities

**Additional impacts:**

- **Water:** Small mountain glaciers disappear – water supplies threatened in several areas
- **Ecosystems:** Extensive damage to coral reefs
- **Extreme weather events:** Rising intensity of storms, forest fires, droughts, flooding and heat waves
- **Risk of abrupt and major irreversible changes:** Increasing risk of dangerous feedbacks and abrupt, large-scale shifts in the climate system

**SOURCE:** Stern Review

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Summer 2003: European Heat Wave

• 35,000 premature deaths

Global warming’s twin, ocean acidification, is here

The impacts of CO₂ emissions on the marine realm have surfaced in Pacific waters.

Since the Industrial Revolution, oceans have absorbed an estimated 525 billion metric tons of human-generated CO₂ and become 30% more acidic. This is decreasing the amount of carbonate available for marine organisms such as plankton and corals to construct calcium carbonate shells and skeletons. The effects have remained virtually invisible thus far, but now, in a study published online May 22 in Science (DOI 10.1126/science.1155676), researchers report detecting acidified surface water along the west coast of North America.

Deep ocean waters normally are more acidic and have higher CO₂ levels than shallow waters because decomposing organic matter sinks and makes deep water acidic, and deep water contains CO₂ absorbed when the water last circulated to the surface. Seasonal upwelling propels this deep water onto continental shelves. During the spring of 2007, Richard Feely of the National Oceanic and Atmospheric Administration's...
Climate Change and the Great Lakes

Increased Evaporation and transpiration

More droughts
More floods

Water prices go up

Dryer climate

Lower Groundwater levels

Lower surface Water levels

Infrastructure failures

Small streams dry up

Relocate water intake pipe

Water quality declines

Wetland areas reduce

Less habitat for wildlife

Water prices go up
<table>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water</td>
<td>D-</td>
<td>D</td>
<td>D</td>
<td>B-</td>
</tr>
<tr>
<td>Hazardous Waste</td>
<td>D</td>
<td>D+</td>
<td>D-</td>
<td>D</td>
</tr>
<tr>
<td>Roads</td>
<td>D</td>
<td>D-</td>
<td>F</td>
<td>n/a</td>
</tr>
<tr>
<td>Schools</td>
<td>C+</td>
<td>C+</td>
<td>C-</td>
<td>C-</td>
</tr>
<tr>
<td>Wastewater</td>
<td>D-</td>
<td>D</td>
<td>D+</td>
<td>C</td>
</tr>
</tbody>
</table>

A = Exceptional  
B = Good  
C = Mediocre  
D = Poor  
F = Failing  
I = Incomplete

http://www.asce.org/reportcard/2005/page.cfm?id=103
Are we heading to a disaster?
Biodiversity

• Evolution of species and extinction of others is a natural process

• Species present today represent 2-4 % of all species that have ever lived
Biodiversity


• Between 2000-2050
  – 1 species will be extinct every 44 minutes (low)
  – 1 species will be extinct every 9 minutes (high)
Humans have increased extinction rates by 1000 times.
Indicators of Environmental Health

• 50 % of 6,000 amphibian species threatened with extinction

• 165 species already gone extinct

• Habitat destruction, contaminants, climate change
Human Benefits of Biodiversity

- Ecosystem services
  - Production of food, pharmaceutical and industrial products
  - Carbon sequestration and climate regulation
  - Waste decomposition and detoxification
  - Purification of water and air
  - Pest and disease control

We are part of the environment!
Collapse of Civilizations

Historical factors:
• Deforestation and habitat destruction
• Soil problems (erosion, salinization, and soil fertility losses)
• Water management problems
• Overfishing
• Effects of introduced species on native species
• Human population growth
• Increased per-capita impact of people

New factors:
• Human-caused climate change
• Buildup of toxic chemicals in the environment
• Energy shortages
A Revolution Has Begun…

1. Similar intentions and objectives
2. Large and diverse

http://www.youtube.com/watch?v=93He4cE95o4
WiserEarth... serves the people who are transforming the world. It is a community directory and networking forum that maps and connects non-governmental organizations (NGOs) and individuals addressing the central issues of our day: climate change, poverty, the environment, peace, water, hunger, social justice, conservation, human rights and more. Content is created and edited by people like you. Read more.

Explore
- 108,898 Organizations
- 14,114 People
- 630 Groups
- 3,402 Resources
- 306 Events
- 199 Jobs

Connect
- Create a Profile
- Network with Others
- Find Nonprofit Organizations in your Area

Participate
- Join a Group focused on your issues
- Create a Group
- Spread the Word

Today's Portal: Health Care Access

Today's Organization: Border Heath Initiative

Today's Group: Body of Heath in the BIG ONE

Today's Event: Green Career Workshop

Photo Sources: Top Photo | Today's Portal | Today's Organization | Today's Group | Today's Event
Translation links courtesy of Google
Engineers play a crucial role in improving living standards throughout the world. As a result, engineers can have a significant impact on progress towards sustainable development.

World Federation of Engineering Organizations
Beginning of environmental movement…

1907-1964

Images are from www.rachelcarson.org
1972: Finite Earth...

• Computer modeling that predicted the overshoot

• “We... believe that if a profound correction is not made soon, a crash of some sort is certain. And it will occur within the lifetimes of many who are alive today.”
Demand versus World Biocapacity

Global overshoot: humanity's demand on nature exceeds the biosphere's supply

(www.footprintnetwork.org)
Defne Apul’s Ecological Footprint

Many activities impact our Footprint. If everyone lived like you, we’d need 4.4 Planet Earths to provide enough resources.

To support your lifestyle, it takes 19.5 global acres of the Earth’s productive area.

(21.1 tons of carbon dioxide)

Energy Land
Crop Land
Grazing Land
Forest Land
Built-up Land
Fishing Grounds

Here is how your Ecological Footprint breaks down:

- Food
- Shelter
- Mobility
- Goods
- Services

Can you reduce your Ecological Footprint?

- edit your footprint: go back and retake parts of the quiz
- explore scenarios: explore simple actions to change your footprint
- continue: continue without exploring
HW for 10 Points

• Go to www.footprintnetwork.org and take the quiz on personal footprint. How many planets does it take to support your lifestyle?

• Copy paste your results. Is there any part of your footprint that can be relatively easily reduced without much effort on your part? Discuss.
History...

• 1962: Silent Spring
• 1972: Limits to growth
• 1987: Our common future (Brundtland Commission report)
• 1992: Earth Summit (Rio de Janeiro) – Agenda 21
• 2002: World Summit on Sustainable Development (Johannesburg) – Millenium development goals
Birth of Sustainability

Brundtland (1987) Our Common Future
“development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

More than 350 published definitions
Definition of Sustainability

Three E’s:
ecology/environment
economy/employment
equity/equality
Education for Sustainable Development

The goal of the United Nations Decade of Education for Sustainable Development (2005-2014, DESD), for which UNESCO is the lead agency, is to integrate practices of sustainable development into all aspects of education and learning.

This educational effort will encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, present and future generations.

News

Young winners of “Cities around the World” meet in Paris
19-06-2008 (UNESCO) - Young winners from 30 countries of the “Cities around the World” contest, organized by Veolia Environnement, gathered in Paris, France on 13 June. - More

The Contribution of Early Childhood Education to a Sustainable Society
29-05-2009 (UNESCO) - “The Contribution of Early Childhood Education to a Sustainable Society” explains how to educate and prevent further degradation of our planet and contributing to a sustainable society where values of human rights, peace and justice
High-Level Event on the MDGs

World leaders came together in New York on 25 September 2008 for a high-level event convened by the UN Secretary-General and the President of the UN General Assembly to renew commitments to achieving the Millennium Development Goals by 2015 and to set out concrete plans and practical steps for action.

What's Going On?

International Review Conference on Financing for Development: Financing for Development

Heads of State and Government ministers gathered in Doha, Qatar, in early December for a long-planned conference to make recommendations on key inputs required to fuel development -- trade, aid, investment, debt alleviation, national resource mobilization and effective international financial architecture. The conference had succeeded in reaffirming that development assistance should continue even throughout the current financial crisis, the Secretary-General's Special Envoy for the Conference said. Press Release
Target 1:
Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources

- Immediate action is needed to contain rising greenhouse gas emissions
- Success in limiting ozone-depleting substances is also helping to mitigate climate change

Target 2:
Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss

- Marine areas and land conservation need greater attention
- Deforestation slows and more forests are designated for biodiversity conservation
- The number of species threatened with extinction is rising rapidly
- Fish stocks require improved fisheries management to reduce depletion

Target 3:
Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation

- Almost half of the world’s population face a scarcity of water
- More people are using improved sanitation facilities, but meeting the target will require a redoubling of efforts
- In developing regions, nearly one in four uses no form of sanitation
- Though access to improved drinking water has expanded, nearly one billion people do without
- Women shoulder the largest burden in collecting water

Target 4:
By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers

- Simple, low-cost interventions could significantly improve the lives of many slum dwellers
Water Use in the U.S.

Thermoelectric power, 48%
Public supply, 11%
Irrigation, 34%
Aquaculture, less than 1%
Livestock, less than 1%

Mining, 1%
Industrial, 5%
Domestic, 1%
Issues that will affect engineers
Population

Population (in billions)

10
8
6
4
2

2000
6.1 billion

Less developed countries

More developed countries

1750
1800
1850
1900
1950
2000
2050
2100
2150
Ways of Dealing with Environmental Problems

Taken from Davidson et al. (2007) available at: http://pubs.acs.org/subscribe/journals/esthag/41/i14/html/071507viewpoint_davidson.html
Health/sanitation

Types of environmental risks that lead to greatest loss of disability-free days of a person’s life in the world

- 46% Unsafe water, sanitation, and hygiene
- 33% Indoor air pollution from use of solid fuels
- 11% Lead exposure
- 5% Urban air pollution
- 5% Global climate change
Circle of Blue | WaterNews
Reporting the Global Water Crisis

U.S. faces era of water scarcity
Profligate use hurts in unexpected places
Restrictions hamper growth; quests for sustainable management
US Government Accountability Office 2003 Survey Results

(GAO – 03-514)
Sources of Freshwater Impairment in the United States

per cent of water body length (for rivers) or area (for lakes and estuaries)

Source of figure: *Global Environment Outlook: environment for development (GEO-4)*
http://www.unep.org/geo/geo4/media/graphics/Zoom/6.44.jpg
Energy and Climate

Source: http://www.ipcc.ch
Planetary Destabilization

Wednesday, January 14, 2009

Dispatch from Denver: Making Climate Change THE Issue
by Jeffrey Allen

DENVER - Author and environmental leader David Orr is upset about the corruption of language in the United States. He doesn't like how some groups have co-opted phrases like "pro-life" and "conservative" to promote their own political agendas, which often have little to do with saving lives or acting conservatively. But the greatest travesty, he says, is the way Americans throw around the term "global warming."

"This isn't 'global warming,'" he exclaims with an air of severity and deep concern. "This is planetary destabilization. And it's already begun. The question is: How do we arrest this before it gets to the point of catastrophe?"

Orr joined a panel of top climate scientists and activists this
Toxic Chemicals

• Traditional Contaminants
  – Metals (Cd, Zn, Pb, Cu), PCB, DDT, benzene
Road Runoff Sampling
New Findings…

• Traditional Contaminants
  – Metals (Cd, Zn, Pb, Cu), PCB, DDT, benzene

• Emerging Contaminants
  – Fire retardants (PBDE)
  – Hormones
  – Prescription and over-the counter therapeutic drugs
  – Fragrances
  – Cosmetics
Is Fire Retardant A Harmful Toxin?

Exclusively: Scientists, Lawmakers Raise Red Flags About Fire-Retardant Compound In Everyday Goods

WASHINGTON, May 19, 2008

For decades, Americans have depended on special chemicals to protect them from fire. But now, there are serious questions about the safety of those chemicals. Two states have already banned them, and six more are considering it. CBS News correspondent Wyatt Andrews has this exclusive report. Be sure to tune in to tonight's CBS Evening News for part 2 of this investigation.

She grew up on an island off the coast of Maine, but when Hannah Pingree had her blood tested, she found 18 different flame retardant chemicals in her system.

"It makes me angry that I could have a child in the womb and don't know if they are going to live or die," she said.

(CBS)
Finite Resources

Figure 4. U.S. flow of raw materials by weight, 1900–98. The use of raw materials dramatically increased in the United States throughout the 20th century (modified from Matos and Wagner, 1998, fig. 3).
Companies getting on board with the sustainability revolution…
Sustainability

Wal-Mart’s Support For Farmers Adopting Sustainable Practices Yields Ear...

4/7/2008 - Wal-Mart today announced it will feature Earth Month t-shirts made from transitional cotton in support of farmers making the change from conventional fa...

> Read more... 1 2 3 4 5

Topic Overview

At Wal-Mart, we know that being an efficient and profitable business and being a good steward of the environment are goals that can work together. Our environmental goals at Wal-Mart are simple and straightforward: To be supplied 100 percent by renewable energy, to create zero waste, and to sell products that sustain our resources and the environment.
Welcome to our 2007/8 Sustainability Report

"Ford is becoming smaller, leaner, more globally integrated and more focused on meeting customers' needs and wants. It is also a company with sustainability at the heart of its business. Our vision for the 21st century is to provide sustainable transportation that is affordable in every sense of the word: socially, environmentally and economically."

Alan R. Mulally President and Chief Executive Officer

Using This Report
This report is aligned with the Global Reporting Initiative (GRI) G3 Sustainability Reporting Guidelines, at an application level of A.
Triple Bottom Line At Companies

Sustainability at Owens Corning

Owens Corning is a world leader in building materials systems and composite solutions, delivering a broad range of high-quality products and services. Our products range from insulation, roofing, siding and manufactured stone veneer used in residential, commercial and industrial applications, to glass fiber used to reinforce composite materials used in transportation, electronics, marine, wind energy and other high-performance markets.

As a sustainable company, Owens Corning creates value for our customers and shareholders, positively impacts the environment and enhances the lives of those with whom we interact.
**Buckeye Cable:**
Channel 204

**DirectTV:**
Channel 286
What Does All this Mean to Scientists and Engineers?
Traditional
Chemistry
Math
Microbiology
Hydrology
Engineering design

Sustainable
Chemistry
Math
Microbiology
Hydrology
Ecology
Engineering design
Economics
Sociology
Politics
Technology
Business
We need to think in greater temporal and spatial scales

Taken from Mihelcic et al. (2003)
Our designs should work with nature, not against nature

Treatment wetlands
Soil bioengineering
Industrial ecology
Restoration ecology

Biomimicry: Asknature.org
Traditional
Chemistry  
Math  
Microbiology  
Hydrology  
Ecology  
Engineering design

Sustainable
Chemistry  Economics  
Math  Society  
Microbiology  Politics  
Hydrology  Technology  
Ecology  Business  
Engineering design

Linear thinking  →  Non-linear thinking
Reductionist approach  →  Holistic approach
Near future  →  Future generations
Regional analysis  →  Global analysis

The problems that exist in the world today cannot be solved by the level of thinking that created them.  Einstein
Life Cycle Thinking is a Must for Engineers

Image taken from: http://www.ami.ac.uk/courses/topics/0109_lct/
Table of Contents
(PDFs available for downloading.)

Lester R. Brown

Plan B 3.0:
Mobilizing to Save Civilization
2008

 Entire book (pdf)
 Data sets

1. Entering a New World (pdf)
   A Massive Market Failure
   Environment and Civilization
   China: Why the Existing Economic Model Will Fail
   Mounting Stresses, Failing States
   A Civilization Tipping Point
   Plan B—A Plan of Hope

PART II. THE RESPONSE—PLAN B
7. Eradicating Poverty, Stabilizing I
   Universal Basic Education
   Stabilizing Population
   Better Health for All
   Curbing the HIV Epidemic
   Reducing Farm Subsidies and Debt
   A Poverty Eradication Budget
   Chapter 7 Data (xls)

2. Restoring the Earth (pdf)
Remaking the Way We Make Things

• Being less bad is no good
• Circulated infinitely in industrial cycles ... without loss of quality or damage to our environment or ourselves
• Downcycling
Pessimistic or Optimistic

• Pessimistic: All the science and engineering facts

• Optimistic: All the grassroots movements
  – LEED, Engineers Without Borders, Engineers for Sustainable World, shift in paradigm in engineering education
End of Lecture Exercise

• A green building is being envisioned on Main campus.
  – People will use the restrooms
  – There will be labs
  – There will be rainwater on site
  – We need water and sanitation on site

– As an engineer, which questions would you ask towards sustainable solutions to meet human needs while working with nature?

  • NOTE: Don’t work against nature
• Thank you