Sustainability – An Overview

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Outline

- Sustainability
  - Considerations
  - What is our ecological footprint?
- Greenhouse gases
  - Sources
- Global climate change
- Sustainable energy
  - What are our options?
- Summary
Sustainability

“of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged”

-Merriam Webster
Expanding World Population

1900-2000: World population climbs from 1.6 billion to 6 billion people

2009: World population at > 6.79 billion

2050 Projections: World population to climb to 9.1 billion (U.N. projection)

- U.S.A. - 400 million
- China - 1.39 billion
- India - 1.6 billion
What is Our Ecological Footprint?

Quiz on www.ecofoot.org

This Ecological Footprint Quiz estimates how much productive land and water you need to support what you use and what you discard.

Determines ecological footprint / use with respect to
- food
- mobility
- shelter
- goods/services
Footprint Quiz Questions

› How often do you eat animal-based products?
› How much of the food you eat is processed, packaged and not locally grown?
› How much trash do you generate?
› What type of housing do you live in? What is the size of your home? Do you have electricity?
› How many people live in your household?
More Footprint Quiz Questions

- How far do you travel each week by car?
- What is the mileage efficiency of your car? Do you carpool often?
- How far do you travel by public transportation per week?
- How many hours do you fly each year?
Footprint Calculator Results

Many activities impact our Footprint. If everyone lived like you, we'd need 4.7 Planet Earths to provide enough resources.
Greenhouse Effect

Source: The American Heritage® Science Dictionary
Greenhouse Gases

- Water vapor
Greenhouse Gases

- Water vapor
- Carbon dioxide
Greenhouse Gases

- Water vapor
- Carbon dioxide
- Nitrous oxide
Greenhouse Gases

- Water vapor
- Carbon dioxide
- Nitrous oxide
- Ozone
Greenhouse Gases

- Water vapor
- Carbon dioxide
- Nitrous oxide
- Ozone
- Chlorofluorocarbons (CFCs)
Greenhouse Gases

- Methane
Greenhouse Gases

- Water vapor
- Carbon dioxide
- Nitrous oxide
- Ozone
- Chlorofluorocarbons (CFCs)
- Methane
- Others
Primary Sources of Greenhouse Gas in the U.S.A.

- CO₂ fossil fuel use: 56.6%
- CO₂ (other): 2.8%
- CO₂ (deforestation, decay of biomass, etc): 17.3%
- CH₄: 14.3%
- N₂O: 7.9%
- F-gases: 1.1%

Variations of the Earth’s surface temperature for...

Departures in temperature in °C (from the 1961-1990 average)

the past 140 years (global)

Departures in temperature in °C (from the 1961-1990 average)

the past 1000 years (Northern Hemisphere)
Figure 1.1: Schematic view of the components of the global climate system (bold), their processes and interactions (thin arrows) and some aspects that may change (bold arrows).

Source: ACS-PRF Summer School on Sustainability Science and Technology
Sunspot Activity

1645 – 1715
‘Little Ice Age’

Lower sunspot activity similar to #20 during the 1970’s

Source: http://solarscience.msfc.nasa.gov/SunspotCycle.shtml
Precautionary Principle

When an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.
The Energy Challenge

› If we have to change our energy technologies over a relatively short period of time, where are the best alternatives?

› How should we invest in developing better alternatives?

› What are the drivers that will encourage timely development and market penetration of these technologies?

› Do we also have to change behaviors?
Desirable characteristics of a sustainable energy technology

- Non-depletable on a short time scale
- Low impacts on natural resources -- land, water, etc., across process life cycle
- Accessible and well distributed -- available close to demand
- Emissions free -- no NO\textsubscript{x}, SO\textsubscript{x}, CO\textsubscript{2}, particulates, etc.
- Scalable -- from 1 kW to 1000 MW (t or e)
- Dispatchable -- for base load, peaking, and distributed needs
- Robust -- simple, reliable, durable and safe to operate
- Flexible -- applications for electricity, heat, and co-gen
- Competitive
Barriers to change

US energy infrastructure is large and deeply entrenched

- 400,000+ miles of gas and oil pipelines
- 160,000+ of high voltage transmission lines
- 176,000 gasoline stations
- 1000’s of oil and gas wells drilled annually in the US and Canada
Where do we go from here?
Renewable energy technologies have high sustainability index scores

- Solar
- Wind
- Biomass
- Geothermal
- Hydro

But the quality and availability of renewables vary widely and their costs relative to fossil fuels remain high.
U.S. Renewable Energy Resource Assessment

Solar

Megajoules/m

Wind

Megajoules/m

Biomass

Agricultural resources & residues
Wood resources & residues
Agricultural & wood residues
Low inventory

Geothermal

Temperature <60°C
Temperature >90°C
Geopressured resources
Summary

- Sustainability can be achieved only when resources are used without their depletion
- Population growth contributes more ecological footprints
- Current energy use produces significant greenhouse gases
- Global climate change prediction difficult
- Precautionary principle application
- Renewable technological advances are an integral part of achieving sustainability
Thank You