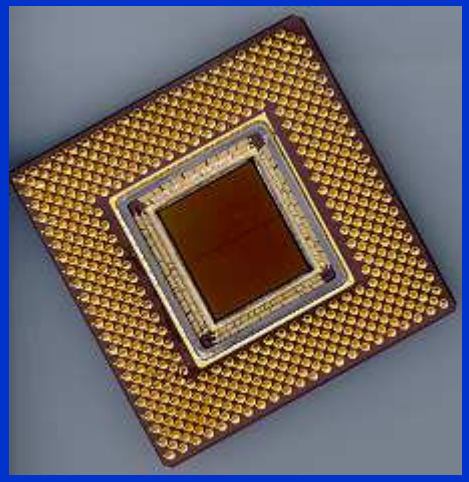


ECE 477 Digital Systems
Senior Design Project

Module 13
Environmental Impact Lifecycle Analysis and Ethical Challenges

Outline

- Environmental Impact Lifecycle Analysis
- Ethical Challenges

Why Study Environmental Impact in Electrical and Computer Engineering?

- Accreditation agencies (ABET) deem it an important part of all engineering curricula, including EE and CmpE

"Environmental issues have become central to much engineering design and practice. Yet environmental questions remain peripheral, and sometimes absent from, most engineering education." ***R. A. Frosch, Harvard University***

Why Study Environmental Impact in Electrical and Computer Engineering?

- Idea of “best engineering practice” – environmental factors are an important element of this

“The university can and must play a central role in developing the concept of industrial ecology and institutionalizing its practice”
J. Ehrenfeld, MIT

Why Study Environmental Impact in Electrical and Computer Engineering?

- Ideas of “environmentally smart engineering education”, “green engineering”, and “sustainable development”

“It is expected that commonplace practice of sustainable development and business practice will evolve over time, either by choice or catastrophe.” ***F. Splitt, Northwestern University***

Why Study Environmental Impact in Electrical and Computer Engineering?

- Potential impact

"Engineers have a greater potential impact on our environmental inheritance than members of any other profession and we, therefore, have a greater obligation and responsibility to see to its care. It is a daunting responsibility, replete with ethical and professional pitfalls. Engineering universities and colleges have a duty to make their graduates aware of these responsibilities." ***M. McPherson, Virginia Polytechnic Institute***

Some Basic Questions...

- What are some of the environmental product lifecycle issues associated with the manufacture, use, and disposal of electronic devices?
- What obligation is there to lengthen the useful lifetime of a product to the extent possible?
- What obligation is there to reduce the energy consumption of a product to the extent possible?
- What would be an effective means for addressing these issues, and what role should government regulation (vs. the “free market”) play?

Some Examples...

- Most electronic products are not inherently biodegradable, resulting in disposal/recycling issues
- Hazardous chemicals are used in the manufacture of integrated circuits and printed circuit boards
- Manufacture of LCD panels requires sulfur hexafluoride (believed to be responsible for 29% of “global warming”), and the lamps contain mercury
- Compact fluorescent lamps (CFLs) contain mercury
- Manufacture of touch screens currently requires raw materials in short known supply (Indium tin oxide)
- Some products that use rechargeable batteries (lead acid, NiCd) are potentially environmentally hazardous

Clicker Quiz

Over its entire product lifecycle (assume 200,000 miles) – including manufacture, regular use, repair/maintenance, and disposal/recycling - the following vehicle will have the smallest overall environmental impact:

A. Chevy Volt (Electric)

B. Toyota Prius (Hybrid)

C. Honda Civic (Conventional)

Reference

Clicker Quiz

Over its entire product lifecycle (assume 200,000 miles) – including manufacture, regular use, repair/maintenance, and disposal/recycling - the following vehicle will have the smallest overall environmental impact:

A. Chevy Volt (Electric)

B. Toyota Prius (Hybrid)

C. Honda Civic (Conventional)

18th International Symposium Transport and Air Pollution
Session 3: Electro and Hybrid Vehicles

Electric vehicle and plug-in hybrid energy efficiency and life cycle emissions

H. Helms, M. Pehnt, U. Lambrecht and A. Liebich

Ifeu – Institut für Energie- und Umweltforschung, Wilckensstr. 3, D-69120 Heidelberg (www.ifeu.de)

"The presented results show, that electric vehicles charged with additional renewable energies lead to a significant improvement in the greenhouse gas balance, whereas other electricity sources lead to no substantial improvement or even higher life cycle emissions."

Clicker Quiz

"The impact of anthropogenic (human-caused) climate change should be the dominant environmental impact product lifecycle consideration and serve as the basis for public policy."

A. agree

B. disagree

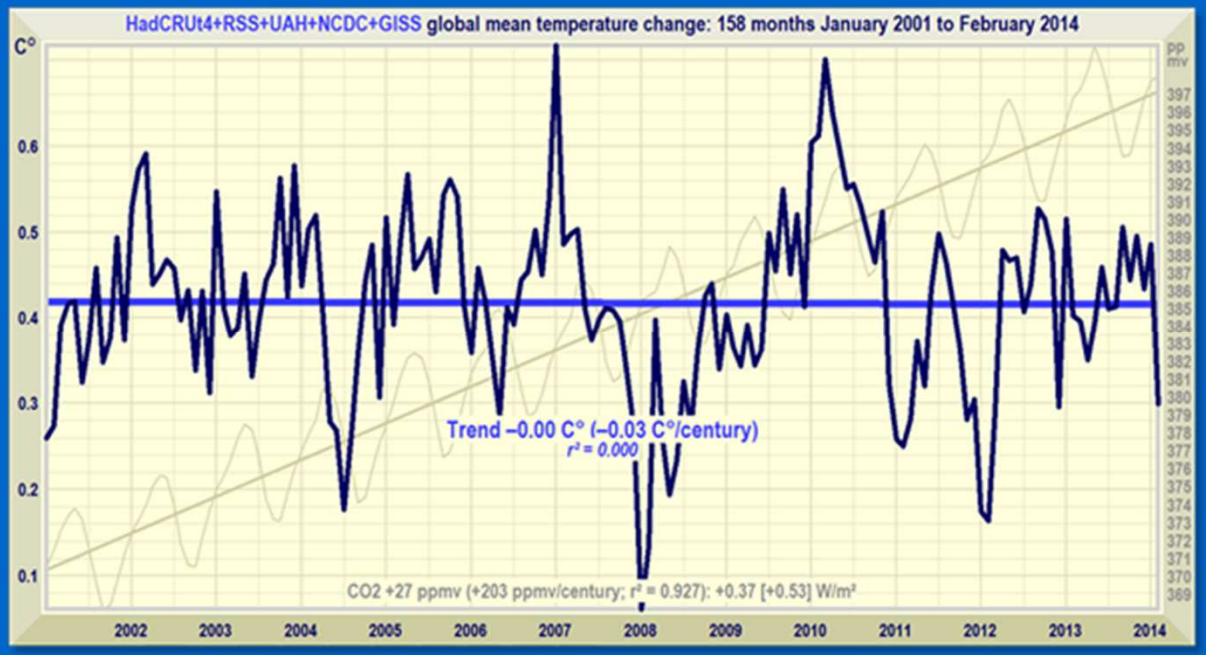
Clicker Quiz

"The impact of anthropogenic (human-caused) climate change should be the dominant environmental impact product lifecycle consideration and serve as the basis for public policy."

A. agree

B. disagree

INCONVENIENT FACT:
There has been no increase in global mean temperature for 158 months, despite a considerable increase in atmospheric CO_2 over this period.



Environmental Lifecycle Impact Analysis

- Outline the environment impact of your product at various stages of its life-cycle
  - manufacture (natural resources, hazardous chemicals, energy)
  - normal use (expected product lifetime, EMI, energy consumed when both “on” and “off”)
  - disposal/recycling (instructions for hazardous waste handling and disassembly/recycling)
- Discuss how you would address each of these environmental impact concerns

Team Exercise – Part 1

Over the life-cycle of the product you are designing, cite a potential environmental impact and describe how you would address it.

Why Study Ethics in Electrical and Computer Engineering?

- Accreditation agencies (ABET) deem it an important part of all engineering curricula, including EE and CmpE
- Virtually all professional societies have a code of ethics
  - IEEE
  - ACM

Some Basic Questions...

- What forms the basis of our views and our understanding of ethics?
- Why is ethical behavior important to society (or, what would happen if the issue of ethics was completely disregarded)?
- How can ethical practices best be learned, promoted, and ensured?

Where in the Computer Engineering Curriculum Should Ethics be Addressed?

- A multi-dimensional issue
  - computer hardware (CPU, peripherals)
  - computer software (embedded code)
  - computer system (hardware-software synergy)

A digital systems senior design project course encompasses all the above, and thus serves as a good context for including ethics in a computer engineering degree program.

What Are Some Consequences of Unethical Practices?

- "Obvious" ones…
  - creating and deploying malware
  - hacking, breaking into systems, sniffing packets
  - stealing passwords or credit card numbers
  - sending "fake" E-mail messages

Are these "harmless pranks"? What are the <u>implications</u> for computer hardware/software engineers?

What Are Some Consequences of Unethical Practices?

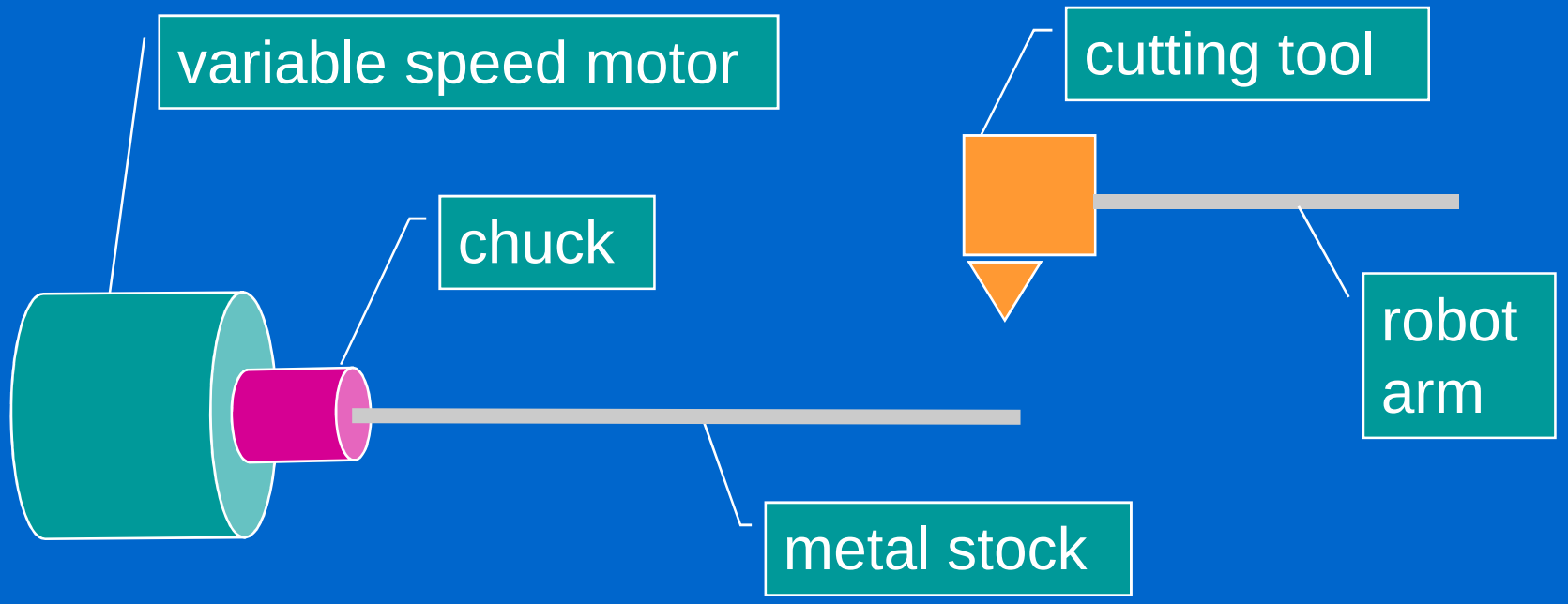
- "Not-so-obvious" ones…
  - shipping hardware or software with known bugs
  - shipping systems that have not been thoroughly tested (certified) for product safety

What are some potential consequences of design flaws such as these?

Focus on Product Safety Issues

- When has a product been “tested enough” to ensure operator safety under various operating conditions and failure modes?
- How long is a company liable for injuries resulting from safety-related product failures?
- Who, in a given company, is responsible for ensuring that a product has been “adequately” and/or “reasonably” designed and tested to ensure operator safety?

Specific Example - A Computer Numerically Controlled Lathe



CNC Lathe Characteristics

- Mechanical system with large inertial forces
- Flying metal debris generated as part of the milling process must be safely contained
- Multiple embedded microprocessors
- Embedded control software (firmware)
- Operator programs written in a special language designed for milling parts (production mode)

Question: What Mechanisms or Design Features Should Be Employed in a CNC Lathe to Ensure Operator Safety?

- Mechanical
  - safety shields to prevent flying debris from hitting the operator
  - mechanical limit switches that shut entire system down if “robot arm” out-of-range
- Computer control hardware
  - feedback sensors to monitor position, motor speed, operating temperature, etc.

Question: What Mechanisms or Design Features Should Be Employed in a CNC Lathe to Ensure Operator Safety?

- Embedded software (firmware)
  - code to monitor feedback sensors, report status, and shut down system if dangerous operating conditions develop
  - mechanism to reset processor/shut down system if software execution disrupted (“watchdog”)
- User “milling” programs
  - automatic identification of commands/parameters that might cause dangerous operating conditions

Question: How Should a Product Be Tested to Ensure It Performs Safely?

- Two aspects of operational safety
  - safety under “normal” operating conditions
  - safety in the event of malfunction
    - **hardware failures**
      - **components (integrated circuits, discrete parts)**
      - **sensors, cables**
    - **software failures**
      - **control code bug**
      - **transient execution error (due to power glitch/noise)**

Back to Focus on Product Safety Issues

- Who, in a given company, is responsible for ensuring that a product has been “adequately” and/or “reasonably” designed and tested to ensure operator safety?
- How should a product be tested to ensure operator safety under all possible conditions?
- What kinds of tests should be performed to “simulate” various failure modes?
- When has a product been “tested enough” to verify “graceful shutdown” in the event of failure?

Ethical Impact Analysis

- Outline the ethical challenges your team would have to resolve in the process of bringing your design to market
  - testing under a variety of operating conditions
  - placement of warning labels
  - providing cautions in user documentation
  - adding safety mechanisms
- Discuss how you would address each of these challenges

Team Exercise – Part 2

In the process of bringing your design to market, cite a potential ethical challenge and describe how you would address it.