Aim

- Understanding and reflection about the impact of the global ICT carbon footprint.
- Understanding the life cycle of ICT products and their energy impacts. Awareness of the standards and programs related to the sustainability of ICT products.
- Awareness of current mechanisms to reduce the energy consumption of ICT products.
- Ability to identify and optimize ICT products/processes/mechanisms/usage scenarios from an energy consumption point of view.
- Understanding and criticism of sustainable ICT solutions.

Outline

1. Introduction to Sustainable Computer Design
   a. The life cycle of ICT products
   b. Phases of the lifecycle (Design, Production, Use, End)
   c. e-waste
   d. Life Cycle Assessment (LCA)
   e. RoHS EU directive, Selection of hardware (ecolabeling): ENERGY STAR, EPEAT. [1]
   f. Energy metrics.
   g. Power aware computing. Dynamic and static consumption of CPUs

2. Power Management, ACPI
   a. CPU, Hard disk, Graphic chipsets, Display, Network interfaces, System.
   b. ACPI Specification. System, CPU and device power and performance states. ACPI hardware and software programming model.
   c. Processor configuration and control: CPU voltage and frequency scaling, CPU idle modes.
   d. Device configuration and control. Waking and sleeping the system. Battery management.

3. Datacenter Basics
   a. Datacenter tier classifications
   b. Datacenter power systems
   c. Datacenter cooling systems
   d. Metrics for data center efficiency.
   e. Energy proportional computing.
   f. Virtualization.
   g. The cloud.
   h. Initiatives: ENERGY STAR, EU Data Centre Code of Conduct.

4. Datacenter Power Provisioning
   a. Power distribution
   b. Inefficiencies in usage of the power budget
   c. Power and cooling systems
   d. Power estimation
e. Power usage characterization
f. CPU voltage/frequency scaling
g. Improving non-peak power efficiency
h. Power provisioning strategies
5. The Carbon Footprint of Cloud Computing
   a. Environmental and economic costs of computing
   b. Description of the supply chain
c. Environmental valuation
d. Economic evaluation of thin-clients
e. Economic and environmental evaluation
f. Constraints and challenges
6. Storage System Energy
   a. Introduction to storage system design
   b. Tape vs. disk storage
c. FLASH based disks
d. Phase-change memory
e. Energy usage in storage systems
f. Modeling energy in storage systems
g. Energy conservation techniques
h. Other important metrics: reliability and availability, performance and maximum throughput
i. Case study: wide-area storage
7. Energy Use of Scientific Applications
   a. Energy usage in distributed systems
   b. Power-performance metrics
c. Power/energy profiling
d. Single node power profile
e. Distributed power profiles
f. Power consumption pattern vs. application characteristics
g. Scheduling resources for energy-performance tradeoff
8. Applications and Energy in Mobile Phones
   a. Health applications of mobile phones
   b. Educational applications of mobile phones
c. Energy scavenging devices
d. Energy use of handhelds
9. Energy of Computer Manufacturing
   a. Energy intensity of computer manufacturing
   b. Mathematical methodology
c. Case study of a desktop computer
d. Uncertainty and caveats
e. Implications for environmental assessment
f. Implications for societal response
10. Introduction to other advanced topics
    a. Smart Grid technology and grid energy efficiency
    b. Nanophotonic technology and its implications
c. Networking energy


**Evaluation Criteria**

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Assignments</td>
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<tr>
<td>Seminars</td>
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<tr>
<td>Exams</td>
<td>20%</td>
</tr>
<tr>
<td>Project</td>
<td>35%</td>
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</tbody>
</table>

**References**

4. Various online papers from well known conferences and journals.
5. Resources gathered at the website of the IEEE Technical Committee on Scalable Computing (TCSC), Technical Area of Green Computing