Course name	Green Computing

Course ID:	40-???	Credits:	3	Program:	Graduate
Prerequisites:				Co-requisites:	
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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

Assignments:	**20%**
Seminars:	**25%**
Exams:	**20%**
Project:	**35%**

References

1. **Luiz Andre Barroso, Urs Holzle, The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines, Morgan & Claypool, 2009.**
2. **Stefanos Kaxiras, Margaret Martonosi, Computer Architecture Techniques for Power-Efficiency, Morgan & Claypool, 2009.**
3. **Lorenz M. Hilty. Information Technology and Sustainability: Essays on the Relationship between Information Technology and Sustainable Development. Books on Demand, 2008. ISBN: 978-3837019704**
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**