Tuesday, 21 October 2008

Reducing the carbon footprint of desktop computer infrastructures

JISC Low Carbon ICT project
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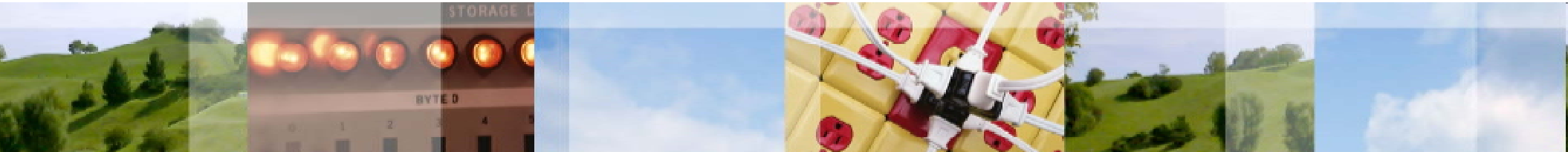
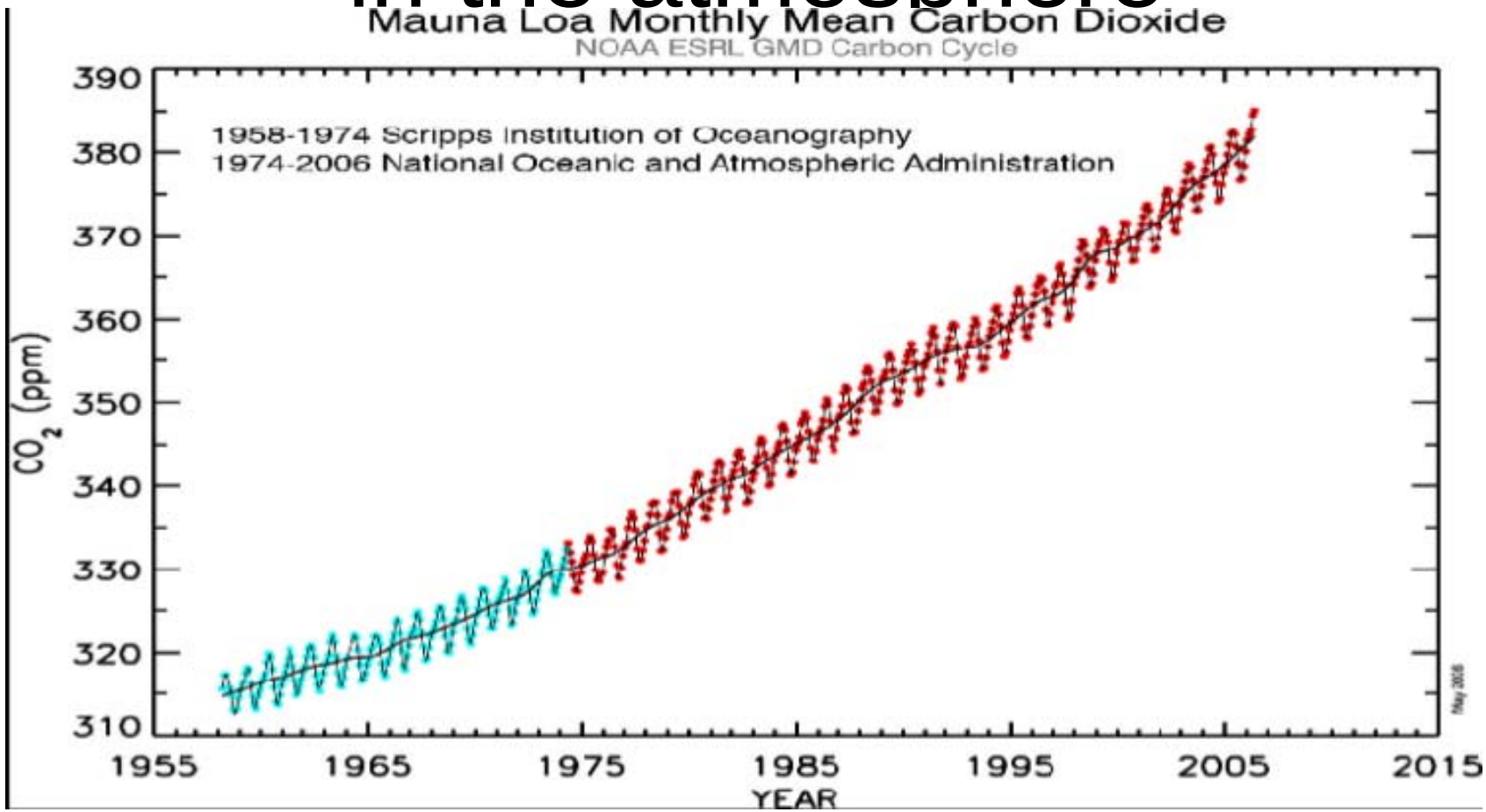
http://projects.oucs.ox.ac.uk/lowcarbonict/



Carbon dioxide is accumulating in the atmosphere



Source: NOAA, 2007

Climate change is happening and serious

- **“Some large-scale climate events have the potential to cause very large impacts”**

Inter-Governmental Panel on Climate Change, 2007

- **“Climate change is a far greater threat to the world than international terrorism”**

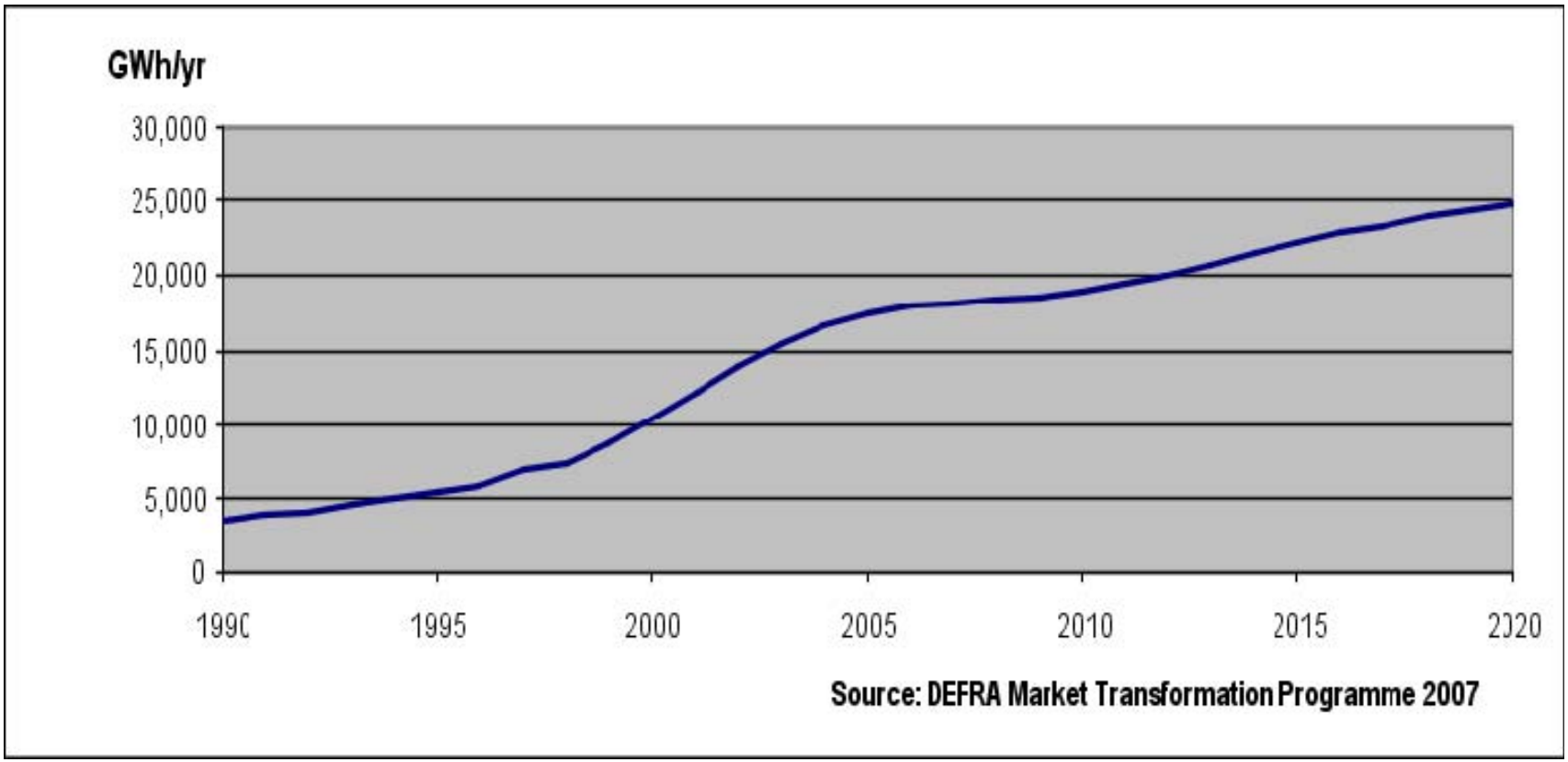
Sir David King, UK Government chief scientific adviser, 2007

UK Government has some ambitious targets

- 12.5% reduction in greenhouse gas emissions by 2012 – our “Kyoto commitment”
- 20% target in CO_2 reduction by 2010
- 26% – 32% in CO_2 legal requirement by 2020 under the Climate Change Bill
- 60% reduction in CO_2 target by 2050, **recently increased to 80%** based on advice of the independent Climate Change Committee

ICT and Carbon emissions

UK non-residential energy use in ICT



- Non-domestic ICT – computers, printers, monitors, etc.
- 7% of non-domestic electricity consumption in 2004
- These figures *exclude* servers and datacentres – estimated to be over 5,000 GWh in 2005 and doubling every 5 years.

ICT and Energy - the scorecard

Energy reduction

- Better control of buildings and processes
- Information substitution for transport energy use
- Improvements in energy efficiency in ICT technology

Energy increase

- Huge increases in processing power
- Low awareness of the scope for ‘easy wins’

Carbon problems for the ICT sector?

- Energy use in ICT is growing rapidly just at a time we need total energy use to begin to decline
- Electricity prices will continue to rise as carbon is “priced”, so costs grow even faster
- Some high energy using ICT technologies may be unusable in key locations due to constraints in the distribution network
- Environmental implications of ICT will face increasing scrutiny – “brand value” is already affected by perceptions of environmental performance

Towards Low Carbon ICT

The perspective of Oxford

Background

- During the summer of 2006, the ECI asked Oxford University Computing Services (OUCS) to find funding for a project to reduce the environmental impact of the University ICT infrastructure, and specifically the energy used by PCs when not in use
- OUCS staff did some research into technologies that could support the ECI requirements and lobbied the Joint Information Systems Committee (JISC) to release funding along these lines
- This project was awarded funding under the programme title: *Institutional Exemplars Initiative – Institutional Concern*

Desktop Computers at Oxford

- The University and Colleges of Oxford have nearly 20,000 students and over 5,000 staff
- It is estimated that this population is served by approximately 12,500 desktop computers
- Around 7,000 of these computers are believed to be permanently switched on
- Wherever possible, switching these computers off when not in use would seem a sensible energy saving option

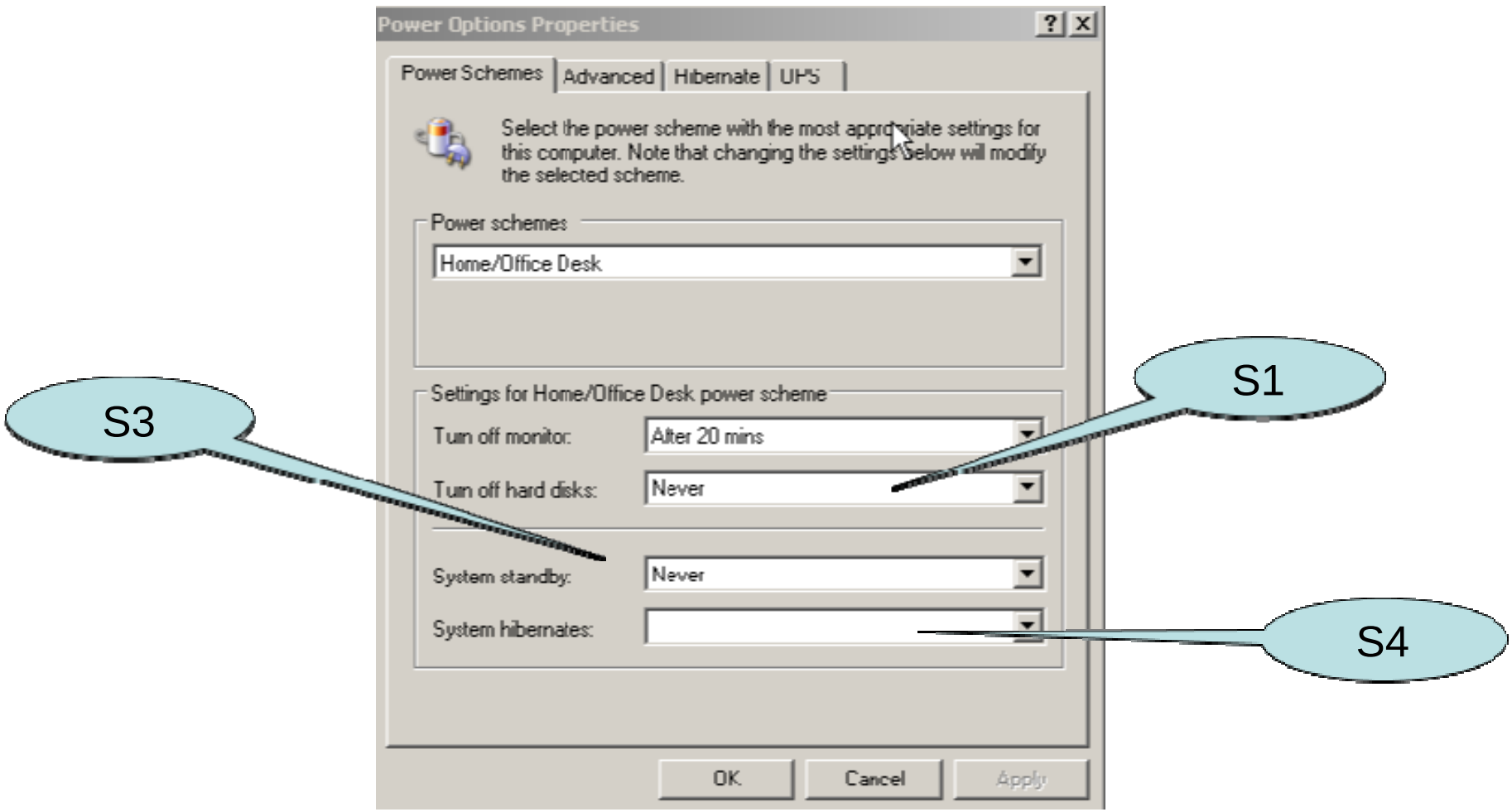
Computers at other Universities

- In May 2006, the University of Leeds found that 70% of its desktop computers ran 24/7
  - The University immediately began a successful campaign to reduce this figure
  - Between 2006 and 2007, overall electricity consumption fell by 2% - previously, it had been rising at a rate of 3% p.a.
- A year earlier, Harvard University found that 60% of its desktop computers were running 24/7 and ran a similar campaign

Energy Consumption of Computers

- Energy consumption varies with the “power state” of the computer
- The Advanced Configuration and Power Interface (ACPI) specification defines six power states:
    - S0: working state or “on-idle”
    - S1: soft standby – hard drive powered down
    - S2: as above with power to CPU cut
    - S3: only the RAM receives power
    - S4: hibernate – save to disk and power down
    - S5: power down – minimal standby state

Power State and Power Management in Windows XP



Power state, power demand and wake-up times

ACPI State	Wake-up time	Power
S0	none	high
S1	2-3s	high
S2	3-4s	fairly high
S3	5-6s	low / v. low
S4	20-30s	very low
S5	>30s	very low

Typical actual power demand in various ACPI power states

- Figures are given for a Dell Optiplex 745:
  - S0: variable - 76 to 114 Watts
  - S1: *no data (S1 being phased out in favour of S3)*
  - S2: *no data (S2 rarely implemented)*
  - S3: 2.7 Watts
  - S4: 1.9 Watts
  - S5: 1.9 Watts
- In states S3, S4, and S5 it is possible to wake a networked computer remotely using Wake-on-LAN (WoL) technology

Wake-on-LAN (WoL) and power management

- Power management software can be used to configure a computer to go into a low power state
- WoL provides the ability to wake the computer from its low power state remotely
- The combination allows for the computer to be powered-down at the end of the day *whilst being left available*:
  - for updates and back-ups by system administrators
  - for users to access their machines remotely
  - for researchers to schedule large computation processes for just as much time as necessary

Anticipated Savings

- Considered for desktop units only – monitors excluded as assumed to go into power saving mode after 20 minutes anyway
- Assumed average desktop power consumption levels:
  - On Power Demand (S0) 78.14 W
  - Sleep Power Demand (S3) 4.79 W
  - Off Mode Power Demand (S5) 3.06 W
    (Figures from DEFRA for 2007 UK average non-domestic stock)

Savings per desktop computer

- Typical assumed desktop usage patterns with power management enabled:
  - On: 45 hrs/week = 3,516 Wh
  - Sleep: 5 hrs/week = 24 Wh
  - Off-mode: 118 hrs/week = 361 Wh

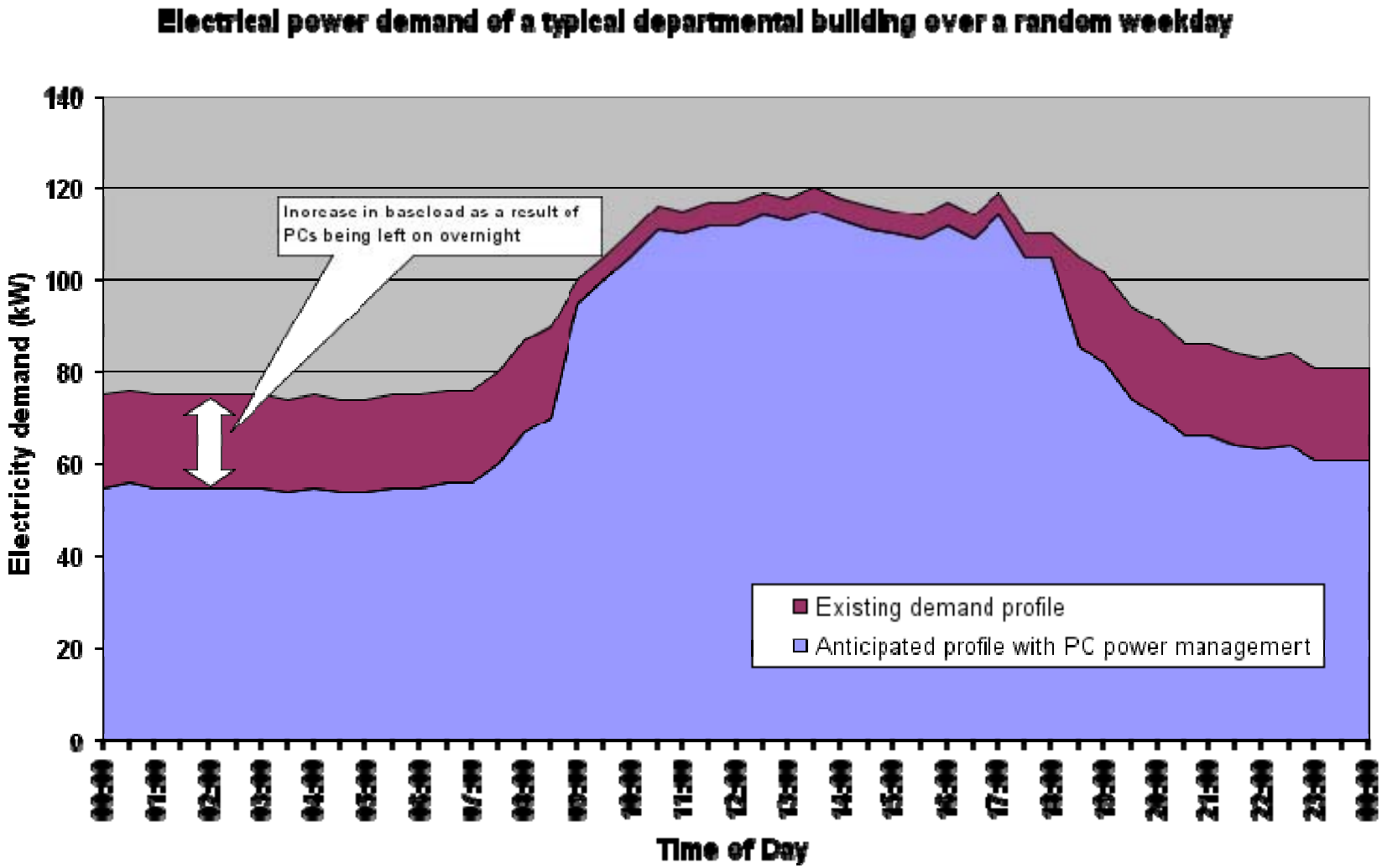
    Total = 3,901 Wh
- Typical desktop usage without measures:
  - On-idle: 168 hrs/week = 13,128 Wh
- Weekly savings per desktop = **9,227 Wh**
- Annual savings per desktop = **480 kWh**

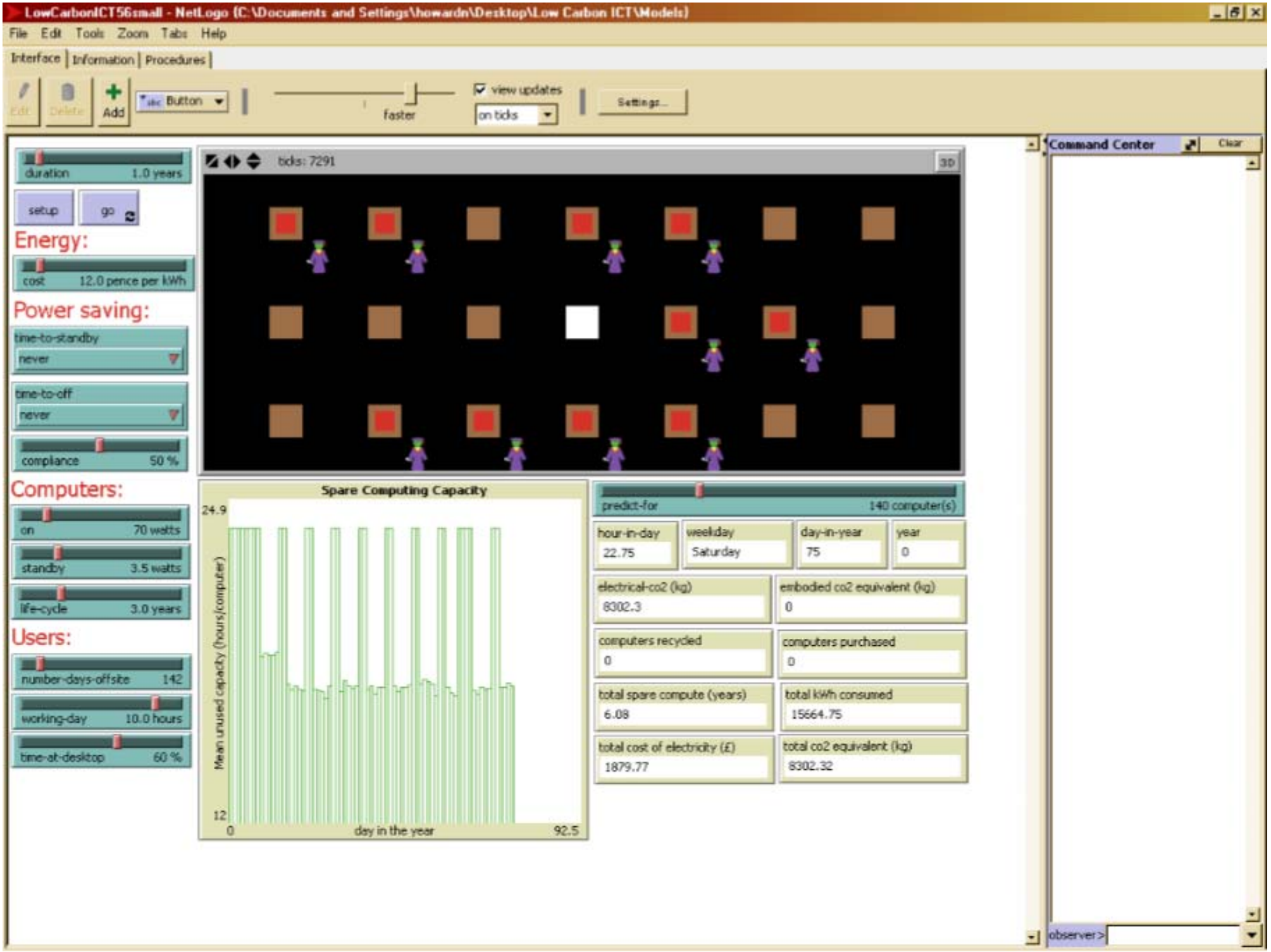
Annual savings at Oxford

- Number of desktops on which savings could be made = 7,000
- Annual savings per desktop = 480 kWh
- Total annual energy savings = 3,360,000 kWh
- Total annual CO_2 savings = 1,800 tonnes
- Total direct annual cost savings = £252,000

- Assumptions:
  - £0.075 per kWh (variable)
  - CO_2 at 0.537kg per kWh of electricity (DEFRA 2008)

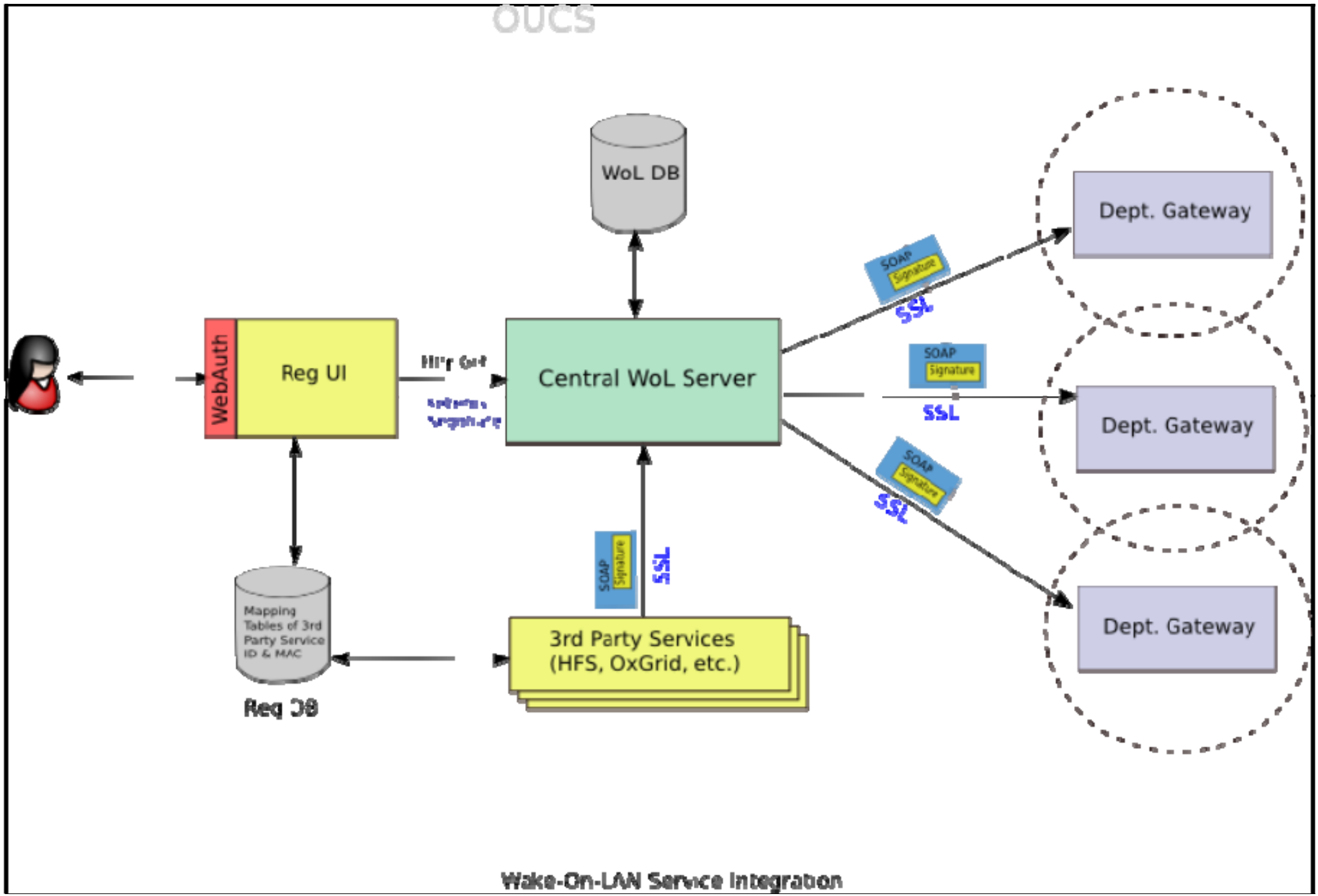
Monitoring the Savings





http://users.ox.ac.uk/~howardn/projects/lowcarbonict/

Wake-on-LAN infrastructure



Supporting other organisations

1. Support Liverpool University in implementing the WoL software (so that other groups can feel more confident they too can adopt this open source software)

1. Work with Liverpool to write comprehensive documentation on ‘automatic power management’ i.e. S3, S4 and S5

1. Create a computer modelling construction toolkit that can be used to gain an in-depth understanding of low-carbon ICT

1. Create a simple network monitoring service that shows how many computers are on at a range of times throughout the day

Do you have any ideas how we can better support other organisations?

Questions?