JISC

# UEA Desktop Computer Power Monitoring and Management

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## Introduction

At the University of East Anglia (UEA) there are around 5,500 UEA owned desktop computer systems[1] in operation. Approximately 4,200 of these systems are used by staff and 1,300 are in student IT areas which are used for a mix of teaching and casual access. Prior to the SISP project the annual power consumption of UEA owned desktop computers was estimated to be 1.8 million KWh, equivalent to 973,000Kg of $CO_2$ emissions and costing £184,000. This represented 5% of UEA's total electricity bill. If desktop printers and student personally owned computers in residences are also taken into account the annual power consumption attributable to use of desktop computers is probably closer to 2.5 million KWh.

UEA's desktop computing provision consists of a range of technical specifications with anticipated differences in performance and power consumption. However, a five year replacement policy and a Managed PC Procurement Service operating with a sole supplier have been in operation for five years, so variation is constrained and understood to a certain extent. For example, because standard office systems are no more than five years old (there are very few exceptions), we know that the power draw of these is on average around 75-80 watts when active for the system unit and 20-25 watts for the monitor.

Prior to the SISP project there were limited power management policies applied to desktop systems. In student IT areas we were aware of significant electrical power wastage because machines were left switched on 24 hours a day, seven days a week. This was to ensure that they were promptly available for use during the core hours, and the scale of provision and lack of sufficient staff resource meant that it was impractical to power them down out of core hours. We also suspected that significant numbers of staff machines were also being left switched on through the night and at weekends, although we had no idea to what extent this was the case. Therefore, reducing power consumption of desktop systems when not being used was seen as a high priority for the SISP project and in particular the systems in IT areas were seen as an 'easy win' owing to the more regular patterns of use in these areas.

With the above in mind the SISP project set about monitoring desktop computer power consumption using sample areas and both real-time measurement and estimation tools. This enabled us to better understand the power consumption of these systems and also gave us a baseline against which we could measure the effects of implemented measures. We then focussed on implementing centrally controlled power management to place all student desktops into a low power sleep state (less than 1.5W on most system units) outside of IT area core hours and during periods of inactivity.

## Executive Summary

In student IT areas where we applied power management (491 PCs in total) we have achieved a 40% saving in power consumption, equivalent to 132,000 KWh per year and a financial saving of £13,464. This equates to an average annual saving per PC of 269KWh and a reduction in running costs of £27 per year. This has been achieved by use of Data Synergy's Powerman software to put systems into 'sleep' mode (<1.5W) out of core hours. When we have rolled out this power management system across all student IT areas it is estimated that a total saving of 348,000KWh per year will be achieved, thus reducing $CO_2$ emissions by 188,111kg and running costs by £35,496. Taking into account the cost of the Powerman software, the saving in operational costs would cover the cost of the software within approximately 2 months. Additional savings will accrue as we start to implement additional power management policies to reduce power wastage caused by daytime inactivity in student IT areas.

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[1] For the purpose of this study the term 'desktop computer' also includes laptop/notebook computers.

Some preliminary investigation using Powerman to put staff PCs into sleep mode when inactive out of hours has shown that this would be problematic due to differences in work patterns and the requirement for some staff to connect to their desktop system remotely. There was also some evidence from comparison of the staff sample areas that power consumption attributable to PC inactivity was significantly lower for those staff groups where previous efforts had been made to educate staff regarding power saving practices. The project has therefore funded a study using the web based CRed system for implementing behavioural change, to determine the effect on energy consumption and $CO_2$ emissions attributable to both IT and non-IT use[2]. Evidence from roll-out of this system in earlier trials at UEA and in local authorities indicates that $CO_2$ emissions can be reduced by as much as 12-15% by using this system to effect changes in behaviour.

Some piloting of thin client devices as student print stations and library information workstations was also undertaken. From this it was determined that there is an operational power saving to be achieved by using thin clients (225KWh per year for a student print station), but the saving is small when compared to savings achievable using Powerman on fat clients. After considering implementation costs it would only be financially viable to replace the student print stations with thin clients and even then the financial saving of replacing all of UEA's 37 student print stations with thin clients would only be £1,538 per year. If thin clients were deployed on a greater scale for a wider variety of applications then savings would be considerably greater, and there are other advantages associated with support costs to be gained. In light of this it has been recommended that investigation of using thin clients on a wider basis be undertaken when UEA has a virtual server and virtual desktop infrastructure in place.

## Methodology and approach

### Power monitoring

Owing to project time constraints, the large number of desktop computers (5,500) and the lack of room level electrical metering, it was decided early on to take an approach of structured sampling. Inventories of desktop computers (not printers) were created from an earlier survey of computers undertaken across departments and by conducting a separate more detailed survey of student IT areas. For the student IT areas the method of room temperature control (air conditioning or natural ventilation) and type of usage (science, non-science, mixed) was also recorded as well as type and age of the computers etc. This survey was done by circulating a questionnaire to departments' IT support staff and also by inspection by SISP project and Estates staff.

Staff and student profiling work was also undertaken to determine proportions of staff and students in science and non-science[3] schools and staff in business/administrative or academic/research roles.

A schematic showing the different types of users, and for students the different types of IT areas they used was created as below.

[2] At the time of writing this report, the study was still ongoing owing to delays with the rollout of the revised CRED system at UEA. A draft report based on earlier implementations of CRED is available from the SIP project website and a final report will appear when the UEA rollout and study has been undertaken.

[3] Science schools included Chemistry and Pharmacy, Computer Science, Biology, Environmental Sciences and Mathematics; all others were categorised as non-science. It could be argued that this is too simplistic a split and that there are significant numbers of staff or students in for instance the Faculty of Health Schools who also undertake very computer intensive work, we felt that given the time and budget constraints it was a reasonable split.

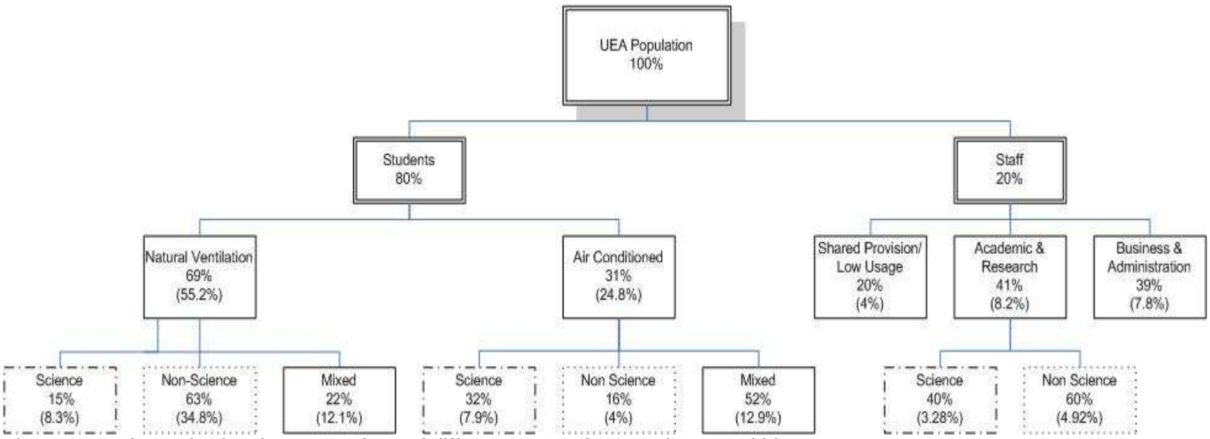


Figure 1 – Schematic showing proportions of different types of use and areas within UEA

The above was then used to develop a sampling rationale which would be representative of all the above types of use. Because physical areas did not map in reality to the above and due to constraints of budget, building layouts, installation practicalities etc, the following sampling scheme of six student and three staff sample areas was arrived at:

| Sample ID | Description | Location | No. of PCs in area |
|---|---|---|---|
| Stu - NV – S | Science students - Natural ventilation | CMP | 16 |
| Stu - NV – NS | Non-Science students - Natural ventilation | ARTS | 67 |
| Stu - NV – M | Mixed students - Natural ventilation | Library | 15 |
| Stu - AC – S | Science students - Air conditioning | CAP | 50 |
| Stu - AC – NS | Non-Science students - Air conditioning | AHP | 26 |
| Stu - AC – M | Mixed students - Air conditioning | ITCS | 81 |
| Sta - AR – S | Science Staff - Academic/research | CMP | 5 |
| Sta - AR – NS | Non-science staff - Academic/research | NAM | 8 |
| Sta – BA | Staff - Business/administration | Registry | 240 |
| Sta – SP | Staff - Shared provision | Dropped due to smallness of sample and disparate location making real-time monitoring impractical | |

Figure 2 – Core sample areas for power monitoring

In the above two types of monitoring were installed

- A hardware based real-time power monitoring solution supplied by Green Energy Options (GEO) which was able to both measure the total power draw of IT equipment and also of selected sample systems within that area.
- Data Synergy Powerman software, which was installed on each desktop system in order to monitor computer activity and inactivity and from this estimate power consumption. This same software was also used to implement power management policies in sample student IT areas.

Note, the Registry sample area was split across different areas within the building and instead of using the GEO system, real-time power monitoring data was obtained from previously installed meters which were connected to the Estates Building Management System (BMS).

In addition to the above samples Powerman software was also installed in the Low Carbon Innovation Centre's (LCIC) staff offices, IT and Computing Service (ITCS) staff offices and all Information Services (IS) managed IT areas.

Data from the above two types of monitoring was used to derive average power consumption figures for computers in each area type and these coupled with sampling profiles used to extrapolate to the whole University and hence calculate the current ('baseline') power consumption of University desktop systems. Data from the GEO system was also compared with Powerman power estimates in order to estimate how far from 'reality' the latter estimates were[4]. Based on this reality check, Powerman was then configured with a standard PC power

[4] Powerman estimates power consumption in KWh from a defined average power draw (Watts) per PC and measurements of 'inactive' (no-one using) and 'active' hours for each PC being monitored.

consumption more typical of UEA than the ‘out of the box’ value. When power saving measures were implemented ‘before’ and ‘after’ measurements from these two systems were then used to determine the power saving achieved.

## Power saving measures

The current energy consumption of University desktop computers was determined from power monitoring data as described earlier. Previously identified energy saving measures (and some new ideas) were evaluated on their potential to save power, their impact on IT infrastructure and service, and also on whether they could actually be implemented during the project life cycle. The measures summarised below were chosen and implemented, and measurements recorded before and after to determine their effect.

- Policy driven power management using Data Synergy Powerman software
- Piloting thin client alternatives to ‘fat clients’ for use as Library information workstations and student print stations.
- Roll out of the CRed System, a web based system for aiding behavioural change so that individuals would engage in more sustainable practices such as switching off PCs when not in use.

### Powerman implementation

This software was installed in all previously identified project sample areas (both staff and student type) and used primarily to reduce power consumption in student IT areas where it was not practical to switch off machines ‘out of hours’ due to their large numbers. The software worked by putting computers into a sleep state where power consumption was very low (less than 1.5W), but which could be awakened quickly by pressing a key or clicking the mouse, thus avoiding long start up times. Use of it to control power consumption due to computer inactivity during core daytime hours was also undertaken in a Faculty managed student IT area and a centrally managed 24hr student IT area. Some preliminary testing of using it to control ‘out of hours’ power consumption in a staff sample area was also undertaken.

Before and after power consumption measurements, both using Powerman estimates and real-time monitoring data from the GEO system enabled the effect of using Powerman to be measured. This proved very successful for reducing ‘out of hours’ power consumption and after initial teething problems had been resolved proved unproblematic. Using Powerman to reduce power consumption due to inactivity during core daytime hours on student systems also proved successful, although this had a more limited scope than for ‘out of hours’ power management because a large proportion of the student IT areas are used for scheduled teaching and it was felt that using this approach during teaching sessions would not be acceptable. Some testing of power management using Powerman was also undertaken in a staff area, but early indications were that savings were not that great and subject to different work patterns of individuals. In the sample there were also a significant number of individuals who needed to leave machines switched on to access remotely out of hours.

More details on power savings achieved using Powerman are in the Outputs and Results section.

### Thin clients pilot

After some research, internal discussion and discussions with suppliers it was decided that any thin client pilot carried out within the project would have to focus on lightweight applications. This was because of time constraints and also because the teaching desktop installed across UEA IT areas contained some applications that were unlikely to be easily delivered by this approach e.g. Matlab and ArcGIS. To be successful in delivering more heavyweight applications via thin client type technology would require more investigation than the allocated time allowed for, time consuming software packaging work and a significant investment in thin client and/or virtual desktop technology and skills.

Two lightweight applications were chosen for piloting thin clients; Library information workstations which have only Internet Explorer and some MS Office viewer applets installed and are used to access Library electronic resources (Library catalogue and electronic journals); and student network printing service print stations where most of the processing is already done on a central server. A server running Microsoft Terminal Services was setup and thin clients from three suppliers were in turn piloted in place of fat clients. Daily power measurements were taken and any problems/comment from students noted. Power measurements from 'fat' clients acting as a control were also recorded and client power savings calculated.

Power consumption of the server blade running Terminal Services was also measured at regular intervals by using a clamp on power meter on the power cable. The server power consumption was then used to offset the thin client savings and arrive at a more realistic estimation of power savings that could be made by using thin clients.

Some preliminary study was undertaken with staff sample areas to determine whether a behavioural approach might deliver benefits and based on this and other research a study of using the CRed System web based carbon reduction tool was also commissioned. The CRed system records individuals' carbon saving actions in the form of pledges which the system then tracks and reports on, calculating the estimated carbon savings achieved. The system also provides a focal point and forum for ideas, bringing individuals together to build local identity and ownership for carbon reduction activities.[5]

Investigation into improved utilisation of DC power generated by photovoltaic panels (as already installed in one of the University's buildings) and incorporation into future building projects was started. However this was prematurely terminated because of lack of progress and the retirement of the principal investigator.

## Outputs and Results

### Power consumption of desktops prior to power saving measures

At the start of the project there were six areas where power consumption was monitored both using real-time monitoring from the GEO system and using estimates derived from the Powerman software system. However, owing to technical difficulties we were only able to obtain data from four student IT areas where both the GEO system and the Powerman system had been implemented. For these four areas the power consumption figures were compared from both systems giving the summary results as in figure 3.

20/5/09-17/6/09 Av. KWh/PC/day

| Area | GEO KWh/Day | PM KWh/day | % difference |
|---|---|---|---|
| AHP | 1.49 | 4.83 | 224% |
| ART | 2.19 | 4.75 | 117% |
| CAP | 1.26 | 4.79 | 280% |
| LIB | 1.34 | 4.8 | 258% |
| Average | 1.57 | 4.7925 | 220% |

Figure 3 – Differences between GEO measurements and Powerman estimates of average daily PC power consumption

As can be seen from the table in figure 3 the Powerman system overestimated the power consumption by on average 220%. This overestimation by Powerman is not surprising, as at this point the wattage for a PC defined in the Powerman software had not been changed from the default value to a value more in line with UEA's PC stock. From previous measurements of power states for a range of PCs found on campus and from the GEO real-time power

[5] For more details of the CRed System see http://www.uea.ac.uk/lcic/cred .

measurements, it was determined that a default wattage of 80W would be more realistic for UEA's computer stock and the Powerman system was configured to this. The Powerman data presented in subsequent sections reflects this adjustment.

**Student sample IT areas**

In addition to the originally selected core sample areas (five student IT areas and four staff areas), all student IT areas centrally managed by the IT and Computing Service also had Powerman software installed. This was because they were seen as a fairly easy target for later applying power management policies. Prior to any power saving measures being applied, the power consumption and activity of PCs in each area was monitored for a 4 week period.

Average daily power consumption figures for each area are presented in figure 4 and the derived average daily consumption figures per PC in the table in figure 5. As can seen from figure 5, there was a similar level of average PC power consumption across all areas with on average PCs consuming 1.84KWh per day of which 82% was attributable to PC inactivity. Extrapolating to a year this gives an annual power consumption per PC of 670KWh at a cost of £68.

| Area | No. of PCs* | Inactive KWh | Active KWh | Total KWh | £ Cost | $CO_2$ Kg |
|---|---|---|---|---|---|---|
| AHP | 24 | 39 | 6 | 45 | £ 5 | 25 |
| ARTS | 63 | 103 | 15 | 118 | £12 | 64 |
| ITCS | 80 | 121 | 12 | 133 | £13 | 71 |
| LIB24 | 115 | 116 | 93 | 209 | £21 | 113 |
| LIB-Other | 16 | 20 | 8 | 28 | £ 3 | 16 |
| CMP/EDU | 17 | 29 | 3 | 32 | £ 3 | 17 |
| CAP | 56 | 99 | 8 | 107 | £11 | 58 |
| Total daily | 371 | 527 | 145 | 672 | £69 | 363 |
| Total annual | | 192,253 | 53,047 | 245,300 | £ 25,021 | 132,597 |

Figure 4 – Average daily power consumption of IT areas before power management

* No. of PCs is an average of the number of PCs sampled per day

| Area | Inactive KWh | Active KWh | Total KWh | £ Cost | $CO_2$ Kg |
|---|---|---|---|---|---|
| AHP | 1.64 | 0.26 | 1.90 | £0.19 | 1.03 |
| ARTS[6] | 1.64 | 0.25 | 1.89 | £0.19 | 1.02 |
| ITCS | 1.51 | 0.15 | 1.66 | £0.17 | 0.90 |
| LIB24 | 1.00 | 0.80 | 1.81 | £0.18 | 0.98 |
| LIB-PUB | 1.27 | 0.53 | 1.80 | £0.18 | 0.97 |
| CMP/EDU | 1.73 | 0.16 | 1.89 | £0.19 | 1.02 |
| CAP | 1.77 | 0.14 | 1.91 | £0.19 | 1.03 |
| Average daily | 1.51 | 0.33 | 1.84 | £0.19 | 0.99 |
| Average annual | 551 | 119 | 670 | £68 | 362 |

Figure 5 – Average daily PC power consumption in IT areas before power management

The chart in figure 6 also shows the power consumption totalled across all sampled areas for each day during the four week monitoring period. As can be seen the active power consumption never rose above 25% of the total and the major component was due to inactive PCs.

[6] This only included around 50% of the machines in the ART area that had power management applied. This was because system replacements in May-June 09 in some rooms within the area prevented data being collected prior to power management being applied and these were excluded from these results.

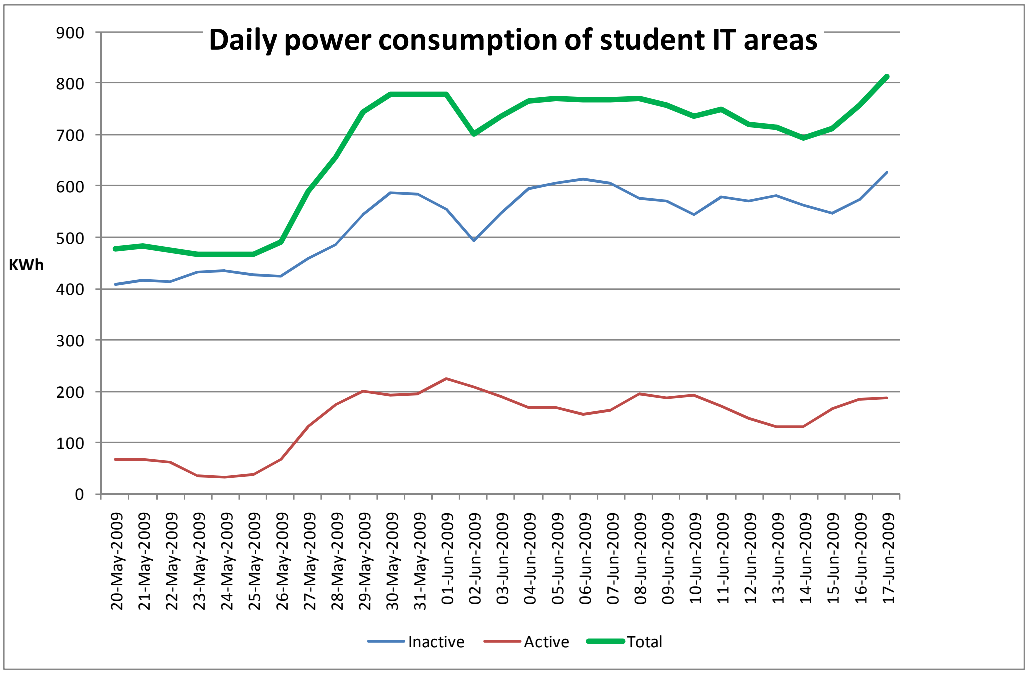



Figure 6 – Daily power consumption across all sampled areas

**Staff sample areas**

The average daily power consumption of sampled staff areas was monitored as for student IT areas, but no power management policies were applied apart from a small sample in ITCS to check out potential implementation issues.

Daily average power consumptions of each sample staff area are shown in figure 7 for the same monitoring period as used for student IT areas. The derived average daily PC power consumption figures are shown in figure 8. From the average daily PC power consumption figures it can be seen that the per PC power consumption was lower than that of student IT areas and the proportion due to inactivity also slightly smaller, but nonetheless still substantial at 62% of the total. In part this will be due to the fact that a significant proportion of staff (estimated at around 80%) do turn their PCs off when they go home in the evening and at weekends.

Another feature of note is that the REG, NAM and LCIC staff PCs consumption is substantially lower than that of the ITCS and CMP staff PCs. There are several reasons for this. Firstly, there is a higher proportion of more powerful systems used in ITCS and CMP. In ITCS there is also a greater proportion of machines left switched on overnight (c.40%) in order that they can be accessed remotely out of hours when required. Also, in REG, NAM and LCIC there has been significant education regarding sustainable practices such as switching off PCs at night.

| Area | PC count | Inactive KWh | Active KWh | Total KWh | £ Cost | $CO_2$ Kg |
|---|---|---|---|---|---|---|
| ITCS staff | 54 | 61 | 21 | 82 | £8.31 | 44 |
| CMP staff | 4 | 5 | 1 | 6 | £0.60 | 3 |
| REG staff | 241 | 96 | 111 | 207 | £21.10 | 112 |
| NAM staff | 8 | 0 | 4 | 4 | £0.46 | 2 |
| LCIC staff | 9 | 3 | 4 | 7 | £0.75 | 4 |
| Total | 315 | 166 | 140 | 306 | £31 | 165 |
| Total annual | | 60,619 | 51,112 | 111,731 | £11,397 | 60,396 |

Figure 7 - Daily average consumption per sample staff area 20/5/09 – 17/6/0

| Area | Inactive KWh | Active KWh | Total KWh | £ Cost | $CO_2$ Kg |
|---|---|---|---|---|---|
| ITCS staff | 1.13 | 0.38 | 1.52 | £0.15 | 0.82 |
| CMP staff | 1.36 | 0.18 | 1.55 | £0.16 | 0.84 |
| REG staff | 0.40 | 0.46 | 0.86 | £0.09 | 0.46 |
| NAM staff | 0.06 | 0.51 | 0.57 | £0.06 | 0.31 |
| LCIC staff | 0.37 | 0.48 | 0.85 | £0.09 | 0.46 |
| Average daily | 0.66 | 0.40 | 1.07 | £0.11 | 0.58 |
| Average annual | | | 390 | £39.78 | 210.81 |

Figure 8 - Daily average PC power consumption in sampled staff areas 20/5/09 – 17/6/09

The profile of daily power consumption totalled across all sampled staff areas is also shown in the chart in figure 9. This clearly shows the drop in power consumption each weekend and the still substantial amount of power wastage due to inactive PCs at the weekend.

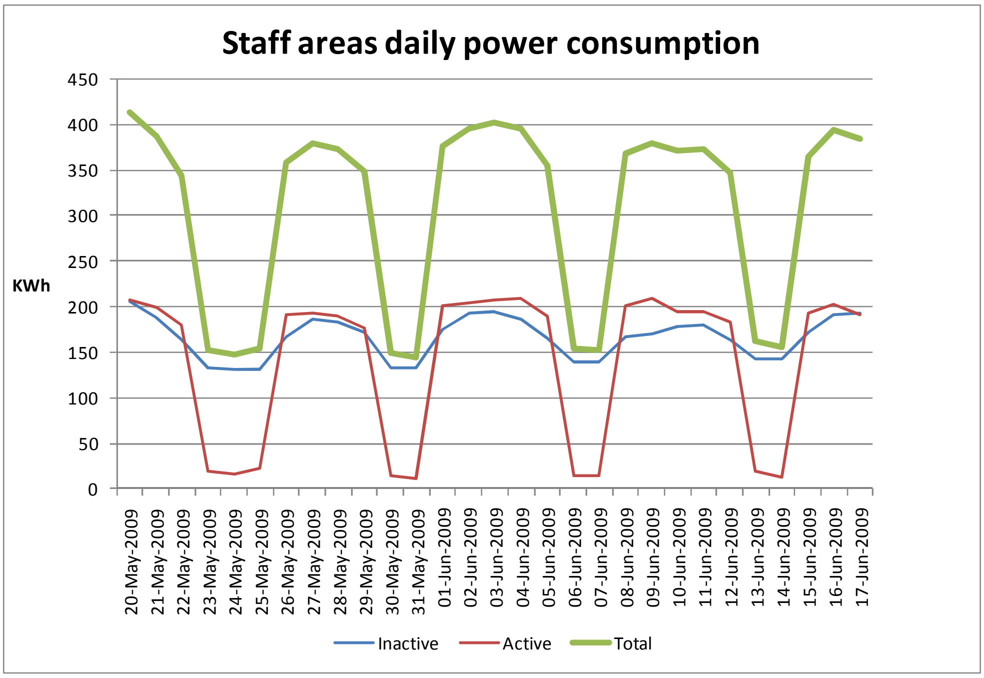



Figure 9 – Daily power consumption across all sampled staff areas

**Using Powerman to implement power management**

For reasons as previously described, Powerman was only used to implement power management policies in student sample IT areas. Of the student IT areas originally monitored there were two, CMP and CAP, which were not selected for power management to be applied. In CMP this was because there had been conflicts between the Powerman software and other specialist software running on the systems and CMP IT support staff needed to focus on getting the systems ready for the start of the next academic year. In CAP the local IT support staff also elected not to have power management policies applied because they preferred to manually switch off systems when not being used overnight (although from Powerman monitoring statistics this did not appear to be happening). In the remaining sample student IT areas Powerman software was used to switch PCs to a sleep state out of core hours and the effects were monitored through to March 2010. In the LIB 24hr and AHP IT areas, rather than implementing out of hours power management an overall inactivity policy was applied whereby systems would automatically enter sleep mode after 30 minutes of inactivity irrespective of the time of day.

As can be see from the plot in figure 10 there was a substantial drop in power consumption following the application of power management policies using Powerman after 17th June

2009. This drop in power consumption averaged about 0.74KWh per day per PC. On an annual basis this was equivalent to 269KWh per PC per year (145.4kg $CO_2$, £27)[7]. For the IT areas where power management policies were applied (491 PCs in total), the annual saving power saving achieved was 132,000 KWh (£13,464). However, when these power management policies have been applied across all student IT areas in the University[8] around 348,000KWh per year of power will be saved, equivalent to 188,111kg of $CO_2$ emissions and £35,496. As monitors are also put into sleep mode when Powerman switches the system unit to sleep around another 80,000KWh would also be saved giving a total saving in excess of 400,000KWh (£40,000).

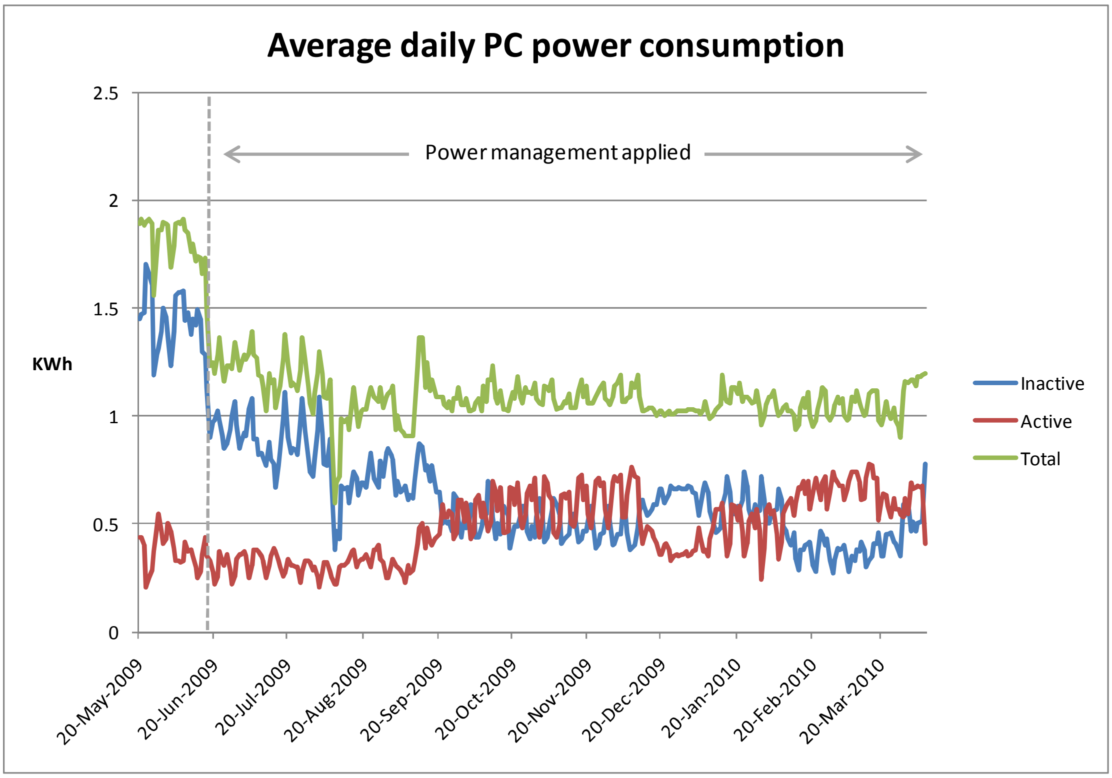



Figure 10

| Area | Inactive KWh/PC | ActiveKWh/PC | TotalKWh/PC | Cost | $CO_2$ Kg |
|---|---|---|---|---|---|
| AHP | 1.48 | 0.13 | 1.61 | £0.16 | 0.87 |
| ARTS101-102 | 0.77 | -0.16 | 0.61 | £0.06 | 0.33 |
| ITCS | 0.91 | -0.40 | 0.51 | £0.05 | 0.28 |
| LIB24 | 0.44 | 0.02 | 0.46 | £0.05 | 0.25 |
| LIB-PUB | 0.58 | -0.08 | 0.50 | £0.05 | 0.27 |
| Average daily | 0.84 | -0.10 | 0.74 | £0.08 | 0.40 |
| Average annual | 305 | -36 | 269 | £27.4 | £145.4 |

Figure 11 – Reduction in average daily PC power consumption after power management (post management – pre-management)

Testing of using Powerman to put PCs into sleep mode when inactive for prolonged periods (more than thirty minutes) during daytime hours was also done and proved positive. This was then applied in one of the department's student sample areas (AHP) and also in the ITCS

[7] This does not include monitors. At UEA TFT monitors consume on average c.20-25W. When Powerman puts computers into sleep mode it also does this with the monitor (i.e. takes it to a state of c.1-1.5W).

[8] Currently the software is installed in all student IT areas under ITCS management and a few faculty managed student IT areas that were sampled in this project.

managed LIB24 IT area (used for 24hr access). Other IT areas were considered unsuitable for implementing daytime inactivity policies because they are used for scheduled teaching and need to be instantly available.

The savings to be achieved by using this approach on staff office machines are less clear. From our samples, many staff already switch of their PCs when leaving work (around 80%) and there are quite varied work patterns both across and within departments. Studies on staff samples within the project show that there are some issues related to staff working out of hours and also those that need to leave their machine on in order to be able to connect to it from home. The warning message and time interval for cancelling sleep mode are quite limited within Powerman and it is felt that until more sophisticated features are enabled in this area, use of the software on staff machines may be limited[9]. In addition, behavioural studies within the project also suggest that approaches to change the overall behaviour of staff regarding power saving may be a better approach and deliver wider benefits (see 'Savings by behavioural change').

## Using thin clients

Our study of using 'thin clients' has been quite limited, choosing only to pilot thin clients in situations where little software was installed locally and where we were confident that there would be few software issues. We chose to use thin clients in two situations; as student print stations and as Library information workstations (used for searching the Library catalogue and electronic journals).

The student print stations required only a small applet in addition to the operating system to operate with the existing student network printing infrastructure. This applet could be easily installed into flash memory in the thin client, requiring no back end thin client infrastructure such as Terminal Services. It is realised that this would not be regarded by many as a true/typical thin client operation. Using thin clients as Library information workstations did however require an additional HP blade server running Microsoft Windows Server and Terminal services. This server had an average power consumption of 168W (1,472KWh per year).

Thin clients from three manufacturers (Wyse C90LE, Dell FX160 and HP T5730) were piloted in both situations. Measurements showed that the most power economical thin client was from Wyse which consumed 0.62KWh per day less power than the 'fat client' control when used as a student print workstation and 1.17KWh per day less when used as a library information workstation. Extrapolating from this to a year across the whole University and assuming each workstation is left switched on all the time (which they are), gives the annual savings as summarised in the table in figure 12 below.

| **Workstation** | **Power consumption KWh/day** | | | **No. of stations** | **Total savings per year** | | |
|---|---|---|---|---|---|---|---|
| | PC Fat client | WYSE Thin client | Saving | | KWh | Kg $CO_2$ | £ |
| Student Print | 0.764 | 0.149 | 0.615 | 37 | 8,306 | 4,490 | £847 |
| Library Information | 1.293 | 0.122 | 1.171 | 10 | 4,274 | 2,310 | £436 |

Figure 12 – Power consumption of machines in thin client pilot

The savings as presented above do not appear that great and might be considered marginal given other power saving measures that could be adopted. If both implementation costs and operational costs are taken into account a somewhat different picture emerges as shown in the tables in figures 13 and 14. As can be seen from the table for print stations, if implementation costs are taken into account and it is considered over 5 years, there is a financial saving of over £7.5k to be gained by using thin clients as student print stations. However, because of the need for a back end Terminal Services infrastructure required for the Library information workstation thin client operation there is no saving to be gained, in fact a small loss.

[9] Pre-release details on the next version of Powerman software suggest that there will be improvements which will assist in this area.

| **Operational and Implementation Costs for 37 Print Stations** | | | |
|---|---|---|---|
| | *Thin clients* | *Fat Clients* | *Difference (Fat-Thin)* |
| Energy costs to run per year (KWh) | 2,026 | 10,264 | 8,238 |
| Energy cost for 5yr lifetime of setup (KWh) | 10,130 | 51,320 | 41,190 |
| | | | |
| Unit cost per KWH | £0.102 | £0.102 | |
| Fiscal cost of operation per year | £207 | £1,047 | £840 |
| Fiscal cost of operation for 5yr lifetime | £1,033 | £5,235 | £4,202 |
| | | | |
| Implementation cost per year | £2,997 | £3,700 | £703 |
| Implementation cost over 5yr life time | £14,985 | £18,500 | £3,515 |
| | | | |
| Implementation Cost + operation cost per year | £3,204 | £4,747 | £1,543 |
| Implementation Cost + operation cost for 5yr life time | £16,020 | £23,735 | £7,715 |

Figure 13. Operational and implementation costs of thin & fat clients as print stations

| **Operational and implementation costs for 10 Library information workstations** | | | |
|---|---|---|---|
| | Thin clients | Fat Clients | Difference (Fat-Thin) |
| Energy costs to run per year (KWh) | 438.00 | 4,708.50 | 4,270.50 |
| Energy cost for 5YR lifetime of setup | 2,190.00 | 23,542.50 | 21,352.50 |
| | | | |
| Unit cost per KWH | £0.10 | £0.10 | |
| Fiscal cost of operation per year | £44.68 | £480.27 | 435.59 |
| Fiscal cost of operation for 5yr lifetime | £223.38 | £2,401.34 | 2,177.96 |
| | | | |
| Implementation cost per year | £1,610.00 | £950.00 | -£660 |
| Implementation cost over 5yr life time | £8,050 | £4,750 | -£3,300 |
| | | | |
| Implementation Cost + operation cost per year | £1,654.68 | £1,430.27 | -224.41 |
| Implementation Cost + operation cost for 5yr lifetime | £8,273.38 | £7,151.34 | -1,122.05 |

Figure 14 - Operational and implementation costs of thin & fat clients as library information workstations.

Because of their low wattage thin clients do produce less heat than fat clients and there would be some additional saving from reducing air conditioning requirements. However, it is not possible to quantify this with any degree of certainty.

There were no service issues and no adverse comments from users during this pilot and power saving considerations aside, the smaller desktop footprint, less moving parts and ease of support for these thin clients suggest that there would be some value in using them more widely particularly where there are few software applications being used and use is largely web based. Wider use of 'thin clients' in situations where more heavy weight applications are used does require more investigation. On our standard student desktop alone, we know of at least two items of software where we anticipate significant problems and where the software supplier does not support delivery via Microsoft Terminal Services or similar. Other thin client methods using newer virtual desktop technology might make use of this type of client more feasible, but there would have to be investment in different IT support skills to support this approach and power requirements at the Data Centre end would also be greater and would have to be investigated.

A full report on the project's thin client pilot is available at:
[www.uea.ac.uk/is/sustainable-ict/outputs](www.uea.ac.uk/is/sustainable-ict/outputs) .

## Savings by behavioural change

Within this project, two studies were undertaken to determine the effect of behavioural change on power consumption from IT.

Firstly, it was noticed from our staff sample areas that there were several staff groups (REG, NAM and LCIC) where initiatives to encourage more sustainable behaviour had been undertaken, for instance in the Registry building where there had been a concerted campaign to encourage people to switch off lights and switch off electrical equipment when leaving work each day. From the Powerman monitoring statistics obtained from our sample areas and as illustrated in figure 15, those areas where such initiatives had been undertaken showed significantly less power consumption per PC and also significantly less attributed to inactivity (PC switched on but not being actively used). The 'well behaved' samples averaged only 0.75KWh daily power consumption per PC compared to the 1.52KWh of the 'less well behaved' samples. Perhaps more significantly, the proportion of power consumption attributable to inactivity in the well behaved samples was almost half that of the others.

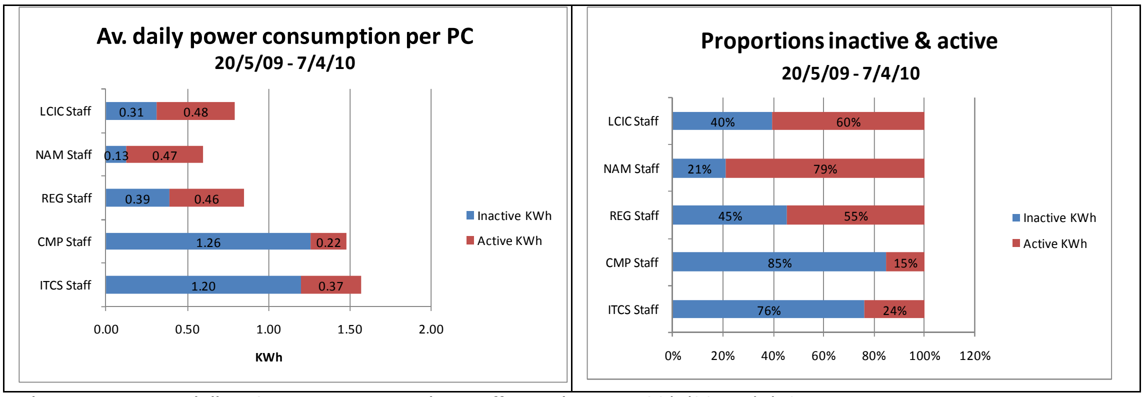
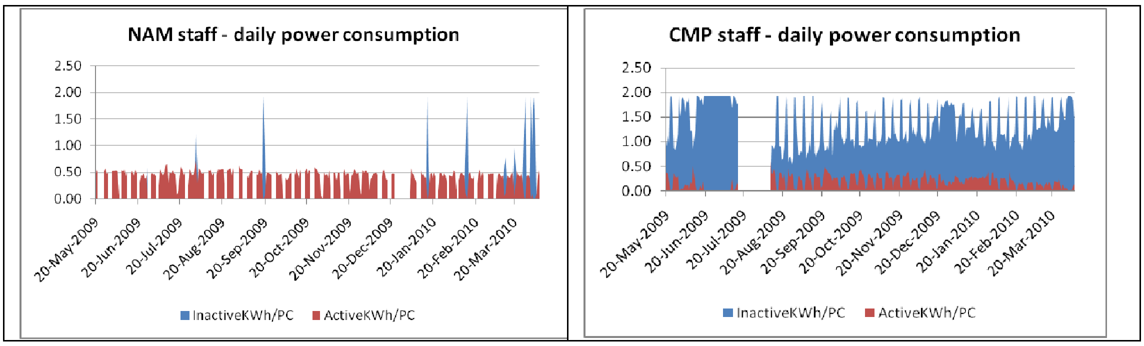


Fig 15 – Average daily PC power consumption staff sample areas 20/5/09 – 7/4/10

The daily pattern of active (PC on and being used) versus inactive (PC on but not being actively used) power consumption also demonstrates differences between the staff sample areas as can be seen in the plots in figure 16. NAM clearly demonstrates the greenest behaviour with average active power consumption generally being higher than the inactive with few exceptions, and the gaps in measurements occurring at weekends demonstrating no PCs switched on (i.e. non for Powerman to record). REG and LCIC staff are less greener in behaviour than those in NAM, but still significantly better than those in ITCS and CMP as demonstrated by the fact that for a significant proportion of the time active power consumption is higher than inactive with inactive power consumption only peaking at weekends, probably due to some PCs being left switched on.

All of this tends to suggest that effort to change behaviour can have a significant effect and it will be interesting to look again at staff areas when the CRED system rollout has been completed later in 2010.



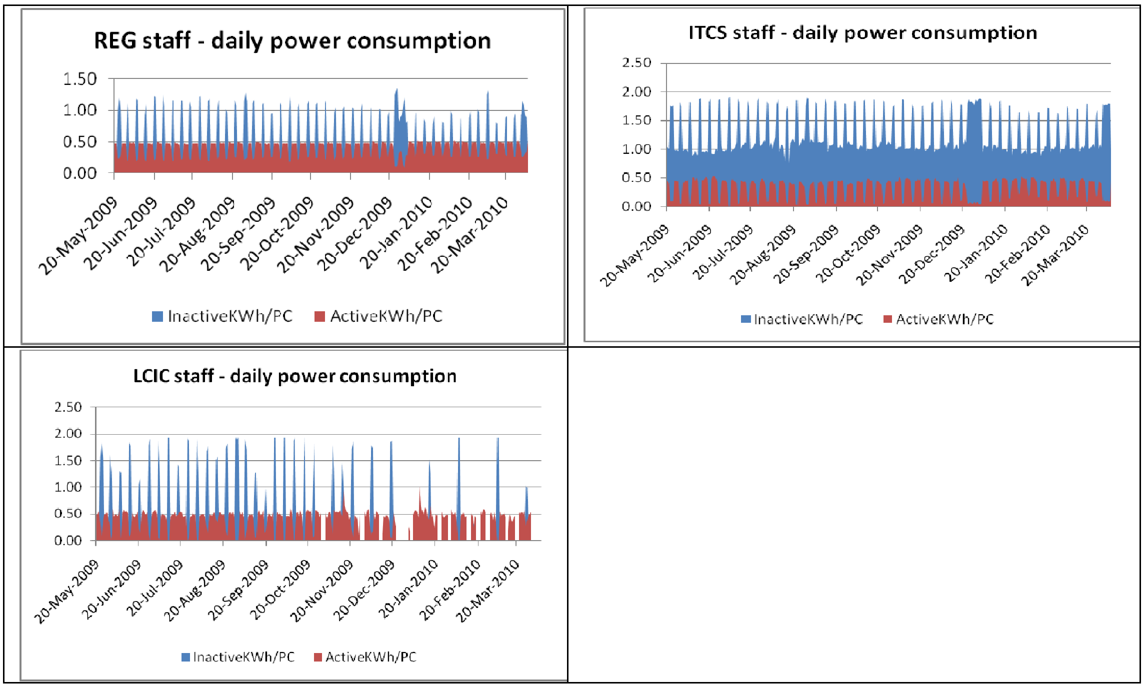


Figure 16 – Plots for each area of daily inactive and active power consumption

Although a seemingly large difference, the small number of sample areas and the small number of computers in some areas meant that extrapolating from this to the whole University could not be done with any great degree of statistical certainty. This along with perceived issues with implementing automated power management on staff computers led to thinking that we could do some work with LCIC and the UEA rollout of the CRed System[10] (online carbon reduction tool) to investigate using behavioural change measures to reduce power consumption.

Based on the above LCIC were commissioned in parallel with their rollout of the new CRed system[11] at UEA to look at the effect on IT use as well as overall effect on carbon footprint. A preliminary study of previous CRed roll-outs elsewhere suggest that significant reductions in power used by IT can be achieved by this approach. The approach is also 'less heavy handed' than imposing power management policies on staff machines as via Powerman and there are much wider benefits in sustainable behaviour to be had by this approach. At the heart of the system is a web based pledge system, so the system also provides an example of how IT can be used as a change agent.

Reports on the LCIC study are available on the project's website at:
[www.uea.ac.uk/is/sustainable-ict/outputs](www.uea.ac.uk/is/sustainable-ict/outputs) .

## Conclusions and recommendations for other HEs

The main conclusions drawn from work on desktop computer power saving are:

- Understanding what you have (inventories) and having procurement policies in place to control the frequency of replacement, number of suppliers and different models is important. The greater the number of suppliers and models the harder it will be to track whether an institution is purchasing and deploying power efficient models. If there is no policy in place to ensure that power consumption is considered in the total cost of ownership, then the need to minimise capital cost and the desire for more processing power (whether required or not), may lead to increased power consumption.
- The tension between keeping PC equipment for longer (saving on embedded carbon in manufacture) and purchasing newer more power efficient models needs to be

[10] For more details of the CRed system see summary description in Methodology section.
[11] The study is still ongoing at the time of this report.

properly considered and managed. It is not necessarily a simple decision. Old kit can consume considerably more power than new kit, so a well thought out rolling replacement policy with a 'maximum life' which is reviewed annually to take account of technical developments would seem to be the most balanced approach. It is interesting to note that at UEA, which has had a five year replacement policy in place for some time, the power consumption of its PCs is typically much lower than figures quoted in studies elsewhere and 'standard' power consumption estimates built into power management software.

- Policy driven automated sleep (to 1.5W or less) of PCs in student IT areas overnight is a quick win and appreciable power savings can be achieved. The ROI is good and savings quickly offset the cost of the software. Using this to decrease power consumption from inactive machines during the daytime is also worth considering, but may not be appropriate where scheduled teaching is undertaken.
- Policy driven power management on staff PCs can be difficult owing to differences in working behaviour. It can also be seen as a very authoritarian approach. Behavioural approaches may well be better for staff machines and there are additional benefits in other areas (changes their thinking generally)
- Thin client technology can make a difference, but won't be suitable for all applications and needs to be coupled with virtual desktop work to implement widely across the organisation. It should also be borne in mind that there doesn't appear to be an easy automated way of putting thin clients into sleep mode like there is with PCs (e.g. using Powerman), so where thin clients cannot be switched off at night, modern power efficient 'fat clients' with power management applied out of hours could give similar power saving results. Deploying thin clients in small numbers will provide only marginal savings over using fat clients and automated power management.

# Appendix

## References

**Desktop power management**
University of Oxford, Low Carbon ICT 'Green desktop computing' resource, http://www.oucs.ox.ac.uk/greenit/desktop.xml . Contains power consumption estimates for PC and monitors, modelled scenarios (always on cf. switched off evenings/weekends/holidays) and green tips and links to other resources.

**Thin client pilot**
Power to the People: Comparing Power Usage for PCs and Thin Clients in an Office Network Environment; Stephen Greenberg, Christa Anderson, Jennifer Mitchell-Jackson; Thin Client Computing, Scottsdale, AZ; August, 2001. http://www.hsp-central.net/Power_Study.pdf . Results from this study broadly comparable to the SISP thin client pilot and confirms the fact that power and monetary savings are proportionately greater the larger the network.

Thin client presentation from Fraser Muir, Queen Margaret University. http://qmu.academia.edu/FraserMuir/attachment/154651/full/The-QMU-thin-client-project Comparison table of thin client and PC on slide 20 broadly in line with findings from the SISP pilot.

## Glossary of terms & acronyms

| | |
|---|---|
| AHP | School of Allied Health Professions, part of Faculty of Health, UEA |
| BIO | School of Biological Sciences, UEA. |
| CAP | School of Chemistry and Pharmacy, UEA. |
| CMP | School of Computer Science, UEA. |
| EST | Estates Division, UEA |
| IS | Information Services UEA, director of which was SISP Project Director. |
| ITCS | IT and Computing Service, UEA. Part of Information Services. |
| LCIC | Low Carbon Innovation Centre. Home to UEA's externally-facing low carbon activities – see http://www.lcic.com/ . |
| NAM | School of Nursing and Midwifery, part of Faculty of Health, UEA. |
| ROI | Return on Investment |
| UEA | University of East Anglia, sometimes referred to in this document as "the University". |