THE UNIVERSITY of EDINBURGH
Social Responsibility & Sustainability

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Lab equipment best practice

Executive Summary

This paper summarises the findings of research undertaken by the University of Edinburgh's Department for Social Responsibility and Sustainability into best practice in laboratory equipment management. It incorporates international best practice as published on the websites of various universities, as well as information gained through judging applications for the Edinburgh Sustainability Awards, and good practices adopted in University of Edinburgh laboratories.

This document describes energy saving actions, including:

Fit timers to switch off equipment (10% electricity saving likely on each item of equipment)

Replace old glassware drying ovens with new (around £300/year saving per oven)

LED microscopes (savings of over £500 per year incorporating reduced replacement lamp purchases and energy)

LED growth cabinets and Incubator Shakers (50% reduction in lighting loads)

Keep centrifuge rotors refrigerated separately (context specific savings)

Ensure mass spectrometers are switched off rather than left 'idle' (context specific savings)

Avoid setting qPCR machines to hold at low temperatures for long periods of time (context specific savings)

The cost of long working hours…

The problem:

Many items of lab equipment are left on 24/7 when users believe the equipment takes too long to warm up prior to use. The energy consumption of some items of equipment does not significantly decrease when the item is in a 'standby' or 'idle' mode. This results in a large amount of unnecessary energy consumption as the equipment often draws a substantial amount of power during times when the lab is unoccupied. Often lab equipment heats up when in use, and thus adds heat to the lab, which can impact on occupant comfort and air conditioning loads (this has not been included in calculations below, which represent only plug-load).

The solution:

Timer plugs can be fitted to many items of plug-in, single-phase electricity equipment in order to realise substantial savings. 7-day timers can be used to programme different operational hours during weekdays and weekends. Most ovens, gas chromatographs and centrifuges reach their temperature in 30-45 minutes.

The varied nature of the lab activities taking place across the University of Edinburgh make an exhaustive list of equipment impractical. In general, you should focus on items of equipment which have heating or cooling functions. Some of the larger energy users are detailed below [1], but given how cheap and easy to use the plug-in timers are, there are unlikely to be any items of equipment which could not achieve reasonable savings through a timer.

Equipment	**TYPICAL rated wattage**	**Estimated TYPICAL average wattage**	**TYPICAL Annual operational hours**	**Annual kWh/unit**	**Annual cost/unit**
Mass spec.	3000	1000	8760	8,760	**£1140**
Gas Chromatograph	1600	800	8760	7,008	**£911**
NMR	3520	1760	8760	15,417	**£2,004**

Equipment	**TYPICAL rated wattage**	**Estimated TYPICAL average wattage**	**TYPICAL Annual operational hours**	**Annual kWh/unit**	**Annual cost/unit**
Freezer (-20)	1000	500	8760	4,380	**£570**
Env'l Chamber	2000	1000	8760	8,760	**£1140**
Water Bath	1000	750	4368	3,276	**£426**
Incubator	850	425	8760	3,723	**£484**
Freezer (-80)	1200	600	8760	5,256	**£683**
Oven (glassware)	1500	850	8760	7,446	**£968**
Ice maker	2400	1200	8760	10,512	**£1367**
Hybridiser	750	375	8760	3,285	**£427**
Incubator/shaker	1500	750	3456	2,592	**£337**

Many of the above items of equipment would be possible to control with a plug in timer controller (c.£10-£20), and so would **easily achieve a payback period under 1 year if 10% energy savings were made**. This has been put into practice by a number of University of Edinburgh laboratories including IGMM, Chemistry and Chancellor's.

Further savings can be made in the 'wash up' area including timers on autoclaves and associated extract fans (e.g. at Roslin Institute).

[1] http://www.goodcampus.org/files/files/52-Lab_equipment_procurement_report_final_25_3_11.pdf

Is your lab oven any better than a café pie display?

The problem:

Glassware drying ovens have, up until now, not been the focus of attention in relation to improving design and efficiency. Old drying ovens are typically uninsulated and thus heat energy is lost to the surfaces of the oven which heat up to potentially dangerous levels while in operation. The thermostatic controls typically are not absolute but just range from 1 - 6, and often are set at maximum for the whole of their working lives. The ovens do not incorporate timers, and so often are operated 24/7. The single-glazed sliding doors of drying ovens often are ill-fitting and allow the heated air to escape into the lab (impacting on occupant comfort and air conditioning loads). In essence, there is little technical difference between an old lab glassware drying oven and the type of oven used to heat and display pies in a cafeteria.

The solution:

Some manufacturers are now looking at drying ovens with a view to addressing the issues noted above and reducing the energy consumption of these items of equipment. Currently only one model is ready for market (the Genlab E3) but in future other manufacturers may also produce similar models, which will introduce competition to the market. The Genlab E3 was originally trialled and tested at the University of Cambridge where it was shown to **reduce energy consumption by around 50%** (or c.£300 annually per unit) through combined use of insulation, thermostatic control, timers and better air circulation design. University of Edinburgh labs have since invested in a number of these ovens, especially the School of Biological Sciences.

Focus on LED microscopes

The problem:

Many labs still operate mercury light source microscopes. These models introduce hazards to the lab environment as the lamps heat up considerably, and there is the risk of mercury entering the lab environment if the lamp shatters. The lamp life is short, which is compounded by the fact that warm up times are long (eating into that limited lamp life). Consequently lab users/managers in imaging suites with mercury light source microscopes spend a lot of time and money replacing lamps. In addition, the discarded lamps must be disposed of as costly hazardous waste.

The solution:

LED light source microscopes are less hazardous and heat up less (and thus use considerably less energy). The LED lamps have long lifespans which are further improved through very short warm-up times meaning the lamps can be switched on and off rapidly without risk of damage, and thus can be set to switch on for a much shorter period of time for any given procedure. LED light source microscopes thus save a lab money in a number of ways: staff time to replace lamps (especially costly if in category 3 restricted areas), lab purchase costs for replacement lamps, waste disposal costs of failed lamps, and reduced energy consumption. In total (**not including staff time**) these items can easily amount to **savings of over £500 annually per microscope, often substantially more**. A number of labs around the University of Edinburgh have invested in LED microscopes including the Roslin Institute, QMRI, SynthSys, Chancellors' and the Biology Teaching Organisation. Further afield, notable investment in LED microscopy has been implemented by King's College London, and Imperial College London.

(Below table is based on 2015 costs)

Technology	Wattage	no. lamps per 20k hours	cost per lamp	cost of lamps per 20k hours	energy costs per 20k hours	lamp disposal costs over 20k hours	total running cost (at 20k hours)	LED saving over 20k hours
Mercury Arc	100	250	£80	£20,000	£180	£500	£20,680	£18,298
Mercury Arc	200-500	100	£300	£30,000	£630	£200	£30,830	£28,448
Mercury Arc	450-1000	44	£450	£20,000	£1,296	£89	£21,385	£19,002
Metal Halide	200	27	£530	£14,133	£360	£53	£14,547	£12,164
Mercury Arc long life	500	14	£500	£7,143	£900	£29	£8,071	£5,689
LED	80	1	£2,237	£2,237	£144	£2	£2,383	N/A

Growth cabinets: a growing problem…

The problem:

Growth cabinets are used to create specific conditions for biological experiments. A number of factors are regulated including humidity, light intensity, light hours, temperature, concentrations of various gases, etc. Often the light units in growth cabinets will be on for long hours in order to simulate certain growing conditions. With most growth cabinets using relatively inefficient fluorescent lamps this leads to substantial energy consumption.

The solution:

LED light sources can replace fluorescent light sources and reduce lighting energy demand substantially while still providing the required light intensity and wavelengths. Cambridge conducted a 2 year trial and found that LEDs give appropriate lighting for the organisms tested (Arabidopsis, wheat, tobacco and tomato). Some LED units can actually provide better light outputs than fluorescent equivalents. **Energy savings of 50-75%[2]** of lighting load could be expected from this action. Lighting load varies from cabinet to cabinet, depending on size and use so savings would be specific, but as a reference point replacements at University of Cambridge have achieved savings of over 300W[3] per cabinet. This would equate to **energy savings of £190 annually per growth cabinet[4]** for University of Edinburgh. In addition, LEDs emit less heat and as such additional savings can be achieved by reduced load on the air conditioning system. Furthermore, the lifespan of LED lamps is substantially greater than fluorescent lamps, meaning that the time and cost of replacing lamps is also substantially reduced.

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[2] Mechanical and Energy Engineering Team, Directorate of Estates and Facilities, University of Manchester
[3] Martin Howes Energy Co-ordinator Department of Plant Sciences University of Cambridge meh73@cam.ac.uk
[4] At University of Edinburgh's electricity price of 9p/kWh and assuming average of 12 operational hours per day

Are your incubator-shakers incubating high bills? Shake it up!

The problem:

As with growth cabinets, incubator shakers incorporate lights in order to recreate appropriate environmental conditions for the growth oforganisms. Currently these lights are almost exclusively relatively inefficient fluorescent lamps. With long hours of operation this leads to significant lighting energy consumption.

The solution:

Replace lamps in incubator shakers with LED. University of Cambridge have conducted a 2 year trial and found that LEDs give appropriate lighting for the two chlorophyll and one diatom species tested. Each incubator shaker was costing £6,000 annually to run (energy and lamp replacement) – this **reduced by 50% with LEDs to save £3,000 annually** [5]. Additional savings result from reduced heat load on the air conditioning system.

More ways to reduce the energy consumption of your lab equipment

The problem:

Lab equipment is often left on for long hours unnecessarily. Below are some tips on ways to reduce the energy consumption (and in some cases also reduce wear and tear) of your lab equipment.

The solutions:

Keep centrifuge rotors refrigerated separately so they are ready immediately without having to keep the whole centrifuge refrigeration system operating.

Studies have revealed that there was little or no energy reduction when mass spectrometers are in the idle mode, so try to switch off completely if not in use overnight/weekends/holidays.[6]

qPCR machines have the option of 'holding' samples at a set refrigeration temperature for a set period of time. This period of time can be 'forever', as is often chosen by lab users who want to run qPCR overnight. The machines are not very efficient at refrigerating samples and consume a lot of energy to hold samples at low temperatures overnight/weekends. Thus, it is recommended that overnight runs are avoided, and if they are absolutely necessary then a higher holding temperature is chosen (over 12^{0}C) rather than trying to chill the samples down to 4^{0}C in a machine which is not ideally designed for this purpose. This action has been put into place by the Roslin Institute and the Hugh Robson Building.

[5] Martin Howes Energy Co-ordinator Department of Plant Sciences University of Cambridge meh73@cam.ac.uk
[6] http://i2sl.org/labs21/conference/2011/abstracts/g6_rumsey.html

Appendix

Lab contacts who can help you with these projects:

Timer controls

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Drying ovens

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LED microscopes

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LED growth cabinets

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LED incubator shakers

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PCR holding times/temperatures

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Useful links

Energy consumption of mass spectrometers

http://i2sl.org/labs21/conference/2011/abstracts/g6_rumsey.html

Thermocycler

http://green.harvard.edu/sites/green.harvard.edu/files/EnergyReductionPotential_KirschnerCaseStudy.pptx%20%28Read-Only%29.pdf

Drying ovens

https://uk.vwr-cmd.com/bin/public/idoccdownload/10094682/Genlab_E3_flyer_FINAL.pdf