Saving Money Through Sustainable Procurement of Laboratory Equipment

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Lisa Hopkinson and Peter James

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See www.goodcampus.org

1. Background

Use of laboratory equipment has many direct environmental impacts, including:

Very high consumption of electricity – about £30-40 million a year in UK universities according to S-Lab research;

Considerable consumption of water, consumables and other resources; and

Creation of waste, both in use and at end of life (when some equipment may require special, and often expensive, disposal, e.g. because it is contaminated).

There is a large indirect impact too from equipment-related requirements for floor space (as building operation has considerable environmental impacts) and, in some cases special requirements for building services such as constant temperature or humidity.

The production of laboratory equipment also has considerable environmental impacts although these are often hard to quantify.[1]

Minimising these impacts is important for environmental reasons, and will be essential if science-based universities are to meet their targets for carbon reduction. As the next section discusses, it also offers significant opportunities for financial savings.

2. Whole Life Costing

Much laboratory equipment is used for many years, and its operating costs will therefore greatly outweigh its initial purchase price. Whole Life Costing (WLC) or Total Cost of Ownership (TCO) calculations provide a means of quantifying and comparing these costs. This is obviously useful for budgetary reasons, but is also a very important mechanism for minimising environmental impacts as energy efficient equipment often costs slightly more to buy. WLC highlights the medium-long term financial case for paying such a premium. Of course, this does not directly address the common barrier in universities that the people purchasing equipment are often not paying energy, water and waste costs, and so have no financial incentive to reduce these. However, revealing the extent of potential savings can make it easier for managers and others to persuade, and will sometimes lead researchers themselves to purchase differently.

From an environmental perspective, it is very important that the WLC exercise includes:

Utilities (energy and water);

Maintenance (which is important as a cost in its own right but also because it can influence levels of energy consumption, so it is important that it is not stinted);

[1] See James P. and Hopkinson L., (2009) Energy and Environmental Impacts of Personal Computing, for a discussion of energy and environmental impacts across the life cycle for IT equipment. Available at http://www.goodcampus.org/files/category.php?siteID=1&catID=8 An updated paper on the life cycle impacts of computers will be available shortly.

Costs of consumables and their disposal (as these create waste at the end of their life); and

End of life disposal costs.

It is very important that the WLC data is related to an output measure wherever possible, e.g. cost and annual kWh per litre of storage capacity for fridges and freezers.

Lifetime energy costs are calculated most simply by multiplying power (kW) by usage (hours/y) by operational lifetime (years) by electricity price (£/kWh). Operational lifetime could be based on warranty periods, but a great deal of equipment is used for much longer than this in practice so figures which reflect this would be more appropriate. (Appendix 3 makes some initial suggestions based on S-Lab experience, and we will try to make more available shortly). For utilities prices, we would suggest the following:

Electricity – current: Institutional cost or 10 p/kWh (including VAT) if this is not available

Electricity – likely: Institutional cost + 25%, or 12.5 p/kWh if the former is not available (making allowance for inevitable increases arising from grid strengthening, replacement of many existing power stations, and development of new renewable sources)

Gas: Current Institutional cost, or 3p/kWh (including VAT) if not available

Water: Current Institutional cost, or £2.30/m^3 if not available.[2]

3. Energy Consumption of Equipment

For most equipment, energy consumption is likely to be the most significant environmental impact. It will also be a very significant component of whole life cost for a number of equipment types. In addition, energy consumption in use is generally easier to measure and/or acquire data about from vendors. Hence, it makes sense to focus on this for most procurement decisions.

There is a wide variation in consumption between different types of equipment, as a result of both differing power draw (e.g. a range of 7-70 kWh/day for different models of -80 freezer), and their pattern of use (e.g. freezers and fridges are generally in continuous operation, whereas a centrifuge may be used only a few times a week or month for short periods). Appendix 1 provides data on the equipment using the most energy in two laboratories that S-Lab has examined in detail, and Appendix 2 shows variations in power draw between different versions of equipment, based on data from Newcastle and York Universities.

The US/EU Energy Star scheme for IT equipment provides a useful model for dealing with energy issues (and is likely to be extended to laboratory grade fridges and freezers, and possibly other laboratory equipment, in the future).[3] It requires vendors to supply power draw (in Watts) for equipment in three

[2] Figures based on typical electricity and gas prices in S-Lab partner universities, and OFWAT figure for average the cost of water supplied and taken away to homes (OFWAT leaflet Your water and sewerage bill 2009-10).
[3] See www.energystar.gov/index.cfm?c=new_specs.lab_refrig_freezers.

different modes: idle, sleep and off[4]. This is then used to calculate an annual Total Energy Consumption (TEC) figure (kWh/y), based on a standardised number of hours in each power mode through the year.

We suggest that university purchasers should be asking vendors for four types of power draw data , i.e. active[5], lower power (idle or sleep), and standby (off as defined by Energy Star), plus the rated (nameplate) figure.[6] Not all of these will be relevant to all equipment, e.g. some may not have a low power and/or standby state. However, the advantage of asking for all four is that vendors can easily state where they are not relevant, but where the data is available it can be used by purchasers to calculate their own estimates of TEC by taking account of their own usage patterns.

It is also important if comparisons are being made to check, wherever possible, the assumptions which underlie power draw data. For example, the power draw of fridges and freezers will be influenced by factors such as ambient temperature, internal temperature, and capacity utilisation.

Calculation of Total Energy Consumption (TEC) is relatively straightforward for laboratory equipment which is always on and in the same power state, e.g. freezers, fridges. It is more difficult for equipment that is not always on, or in the same power state. An assumption has to be made about the percentage of the year that the equipment will spend in different states, which may be difficult for many items of equipment. The boxes below illustrate a TEC calculation for two different types of equipment.

Box 1: Lifetime energy costs (TEC) calculation for always-on equipment (illustrative only)

-80 freezer model 1 has an average (active) power of 0.8 kW and is always on (8760 hrs/y)
-80 freezer model 2 has an average (active) power of 1.3 kW and is always on (8760 hrs/y)

TEC for model 1 = 0.8 kW * 8760 hrs/y * 15 years * £0.125/kWh = £13,140
TEC for model 2 = 1.3 kW * 8760 hrs/y * 15 years * £0.125 kWh = £21,352

Box 2: Lifetime energy costs (TEC) for equipment with different power modes (illustrative only)

Autoclave model 1 has an active power of 1 kW and runs for 5 hrs/day, 5 days/week, 48 weeks/y (1200 hrs/y). It is idle for the remaining time (7560 hrs/y) with an idle power of 0.1 kW.
Autoclave model 2 has an active power of 3 kW and an idle power of 0.2 kW (same usage as model 1)

TEC for model 1 = [(1kW * 1200 hrs/y) + (0.1 kW * 7560 hrs/y)] * 15 years * £0.125/kWh = £3,668
TEC for model 2 = [(3kW * 1200 hrs/y) + (0.2 kW * 7560 hrs/y)] * 15 years * £0.125/kWh = £9,585

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[4] There is no universally accepted definition of power state but for Energy Star idle is defined as where the machine is not asleep, and activity is limited to those basic applications that the system starts by default; sleep is defined as a low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection; and off is defined as the power consumption level in the lowest power mode which cannot be switched off. See

[5] The state in which the equipment is carrying out useful work

[6] The rated power figure will often be the same as active, but there may be circumstances in which they differ.

Another important factor is the presence of energy saving features, such as a low power state function, but also additional features such as automatic shut off, or low energy lighting in growth cabinets.

Appendix 3 suggests a classification of common laboratory equipment into four types with regard to energy consumption:

> Type A – Equipment that has a high power draw, is always on, and is estimated to be a significant factor in laboratory energy consumption. (The main categories of equipment in this type are fridges, freezers and nitrogen storage);
>
> Type B – Equipment that is not always on but is estimated to be a significant factor in laboratory energy consumption, either because it has a high power draw, or because it has a medium power draw and there are large numbers of them (e.g. heating mantles in chemistry labs);
>
> Type C - Equipment that has a high power draw and variable usage, but because of relatively low numbers is not thought to be a significant factor in the energy consumption of most laboratories. (e.g. spectrophotometers); and
>
> Type D - Equipment that has a low-medium power draw and variable usage, and is not therefore thought to be a significant factor in the energy consumption of most laboratories. (e.g. standard microscopes).

4. Other Sustainability Criteria

Information about the following topics can also be helpful in informing purchasing choices:

> End of life – are there any special requirements, and will they have these cost implications? If so, what are they likely to be?
>
> Water – where this is being used, presence of water conservation features (especially continuous cycling) and total annual consumption data for equipment which has a continuous water requirement;
>
> Other environmentally positive (efficiency or other sustainability) features – for example, efficient containers and racking can provide much more effective storage space in fridges and freezers, and therefore reduce the energy and cost overhead per sample stored; and
>
> Product-relevant environmental actions within the suppliers – use of eco design tools, evidence of an environmental management system, product development etc.

5. Holistic Solutions

It is clear that there is considerable potential to reduce the energy consumption of equipment by choosing more rather than less efficient models. However, benefits can be even greater when the purchase of new equipment is combined with an examination of the overall situation that the equipment is operating within, and the opportunities for science improvements, cost savings and reduced environmental impacts that may be available by changing this.

The point is most clearly illustrated by cold storage of samples in fridges, freezers and nitrogen cooled dewars or tanks, when a series of questions can be asked:

Do all currently stored samples need to be stored, or can some be discarded?

What are the least costly (in financial and environmental terms) storage options for different kinds of samples? (e.g. some may be stored in -80 freezers when -30s will suffice, the lowest temperature setting of ultracold freezers may be sufficient for all samples within them).

How can the total amount of cold storage space be minimised? (e.g. only operating larger freezers, efficient racking)?

Once storage needs have been minimised, what is the best equipment to purchase? (Obviously energy efficiency has to be balanced against other factors – e.g. chest freezers have lower energy losses than uprights when they are opened, but use a greater floor area).

How can equipment be operated efficiently after its purchase? (e.g. would an inventory tracking system be worthwhile? can freezers in particular be consolidated into a single space with its own heating and cooling regime to avoid them dumping heat into the lab into summer and thereby greatly increasing the overall cooling requirement?).

The S-Lab case studies on the Blizard Institute at Queen Mary University, and the University of Newcastle, show the scale of the benefits which can be achieved through this approach.[7]

6. Conclusions and Recommendations

Higher education needs to pay greater attention to sustainability issues when purchasing equipment. This is especially true of energy, where there is already potential for considerable whole life cost savings by choosing more energy efficient models. Table 1 overleaf provides a 'target list' of key items of laboratory equipment where more sustainable procurement is likely to be especially beneficial. This comprises Type A and B equipment with regard to energy, and some other equipment types that can have very high water consumption or waste costs, and where alternatives are available for procurement.

The potential to minimise both environmental impacts and costs will increase as more vendors appreciate that this is an important issue for customers, and supply more information about power draw and other aspects of environmental performance. This development – and the quality of data provided (e.g. basing it on standardised assumptions) - can also be encouraged through incorporation of sustainability into sector procurement agreements. This is likely to be the case with the next sector agreement on laboratory equipment, which is being developed by the London Universities Purchasing Consortia (LUPC).

[7] These and other sustainable laboratory case studies available at http://www.goodcampus.org/s-lab-cases/index.php

Table 1: Priority List for Sustainable Procurement of Laboratory Equipment

Equipment Type	**Comment**
Cryogenic Conservation Vessels and cryostats	High energy, always on
DriBlock Heaters, heating mantles and hotplates	Medium energy, high usage and large numbers
Floor-Standing Autoclave (front and top)	High energy, high water consumption, high usage
Freezers (-20, -40, -80)	High energy, always on
Ice Maker	High energy, always on
Incubator (CO2, shaking, standard, sub-ambient)	High energy, high usage, large numbers
Laboratory Refrigerator +4oC	High energy, always on
Liquid Nitrogen Dewars	High energy, always on
Ovens (hybridisation, vacuum and general)	High energy, high usage
Pumps (vacuum and peristaltic)	Medium energy, high usage, large numbers
Rotary Evaporators	Medium energy, high usage, large numbers
Water Baths	Medium-high energy, high usage, large numbers
Water Stills	High energy, high water consumption

Appendix 1: Equipment Energy Consumption in Chemistry and Bioscience Labs

Below are the equipment types contributing most significantly to lab equipment energy consumption in detailed S-Lab audits of sections of the Chemistry Laboratory at the University of Manchester and the Biosciences Laboratory at the University of Liverpool. The tables are based on rated power, and estimates of usage and total numbers. They do not include large (3 phase) or bespoke equipment, and also exclude many items for which a power figure was inaccessible or unavailable. The numbers and types of equipment will also vary significantly from lab to lab so the data is intended to be indicative only.

Table 1.1: Estimated Annual Electricity Consumption of Selected Equipment in the Manchester Chemistry Extension (NB Total Energy Consumption = 2,488,242 kWh, Estimated Scientific Equipment Consumption = 219,773 kWh)

Equipment	Typical peak rated power (Watts)	Assumed average power (Watts) (Power reduction factor in brackets)	Typical usage (hrs/year)	Typical energy consumption per unit (kWh/year)	Estimated numbers[8]	Estimated total energy consumption (kWh/year)	Estimated costs (£/year)
Heaters/Stirrers	500	375 (75%)	648	243	200	48,600	5,832
Mass Spectrometry	3000	1000 (33%)	8760	8760	5	43,800	5,256
Gas Chromatography	1600	800 (50%)	8760	7008	4	28,032	3,364
Rotary Evaporators	1760	590 (33%)	1000	590	27	15,930	1,912
NMR	3520	1760 (50%)	8760	15,418	1	15,418	1,850
Ovens (Chemical)	6000	2000 (33%)	432	864	12	10,368	1,244
Fridges	100	100	8760	876	5	4,380	526
Diaphragm Pumps	370	120 (33%)	1000	120	26	3,120	374
Vacuum Pumps	250	187(75%)	216	40.5	60	2,268	272
Water Baths (Large)	150	112 (75%)	72	81	28	2,025	292

[8] Approximate figures only

Table 1.2: Estimated Annual Electricity Consumption of Selected Equipment in the Academic Section of the Liverpool Biosciences Building (NB Total Energy Consumption = 5,237,743 kWh, Estimated Scientific Equipment Consumption = 1,255,961 kWh)

Equipment	Typical peak rated power (W)	Assumed average power (Watts) (Power reduction factor in brackets)	Typical usage (hrs/year)	Typical energy consumption per unit (kWh/year)	Estimated numbers[9]	Estimated total energy consumption (kWh/year)	Estimated costs (£/year)
Freezer (-20)	1,000	500 (50%)	8760	4380	57	249,660	19,973
Environmental chamber	2,000 (1500-2500)	1000 (50%)	8760	8760	12	105,120	8,410
Water bath	1,000 (500 – 1500)	750 (75%)	4368	3276	31	101,556	8,124
Incubator	850	425 (50%)	8760	3723	24	89,352	7,148
Freezer (-80)	1,200	600 (50%)	8760	5256	14	73,584	5,887
Oven	1,500	495 (33%)	8760	4336.2	11	47,698	3,816
Ice maker	2,400	1200 (50%)	8760	10512	3	31,536	2,523
Hybridiser	750	375 (50%)	8760	3285	6	19,710	1,577
Incubator-shaker	1,500	750 (50%)	3456	2592	7	18,144	1,452
Thermal Cycler (PCR)	800 (250-1600)	400 (50%)	720	288	33	9,504	760

[9] Approximate figures only.

Appendix 2: Measured Equipment Data

The tables below provide data on the energy consumption of existing equipment of various ages/conditions at two universities at Newcastle and York Universities at a given point of time. The data has been kindly provided by the Universities, and has not been corroborated by S-Lab. It may not represent the average energy consumption of a new item of equipment by that manufacturer, and may also reflect atypical conditions of use. It is therefore presented for illustration purposes only.

Also see the Labs21 wiki for more equipment data.[10]

Table 2.1 Performance Variation in -80 Freezers at the University of Newcastle

Model	Capacity (l)	Cost/litre (£)	Annual running cost (@7.3p/kWh)
New Brunswick (Green model)	570	0.54	£306
New Brunswick (Green)	570	0.55	£314
New Brunswick (Green)	570	0.57	£326
Van der Woude Revco	570	0.76	£434
Lab Impex Research	570	0.85	£487
Heraeus	691	0.93	£641
Illshun DF8517	484	1.12	£541
Kaye Sanyo MDF-U70V	728	1.13	£824
New Brunswick	101	1.79	£180

Table 2.2: Measured Energy Consumption of -80 Freezers at the University of York[11]

Brand/model	Capacity (L)	kWh over 24 hour period
Illshun DF8517	570	20.3
Lab Impax Research	570	18.3
New Brunswick Green	570	11.8
New Brunswick Green	570	11.5
New Brunswick U101	101	6.8
Scientemp -80°C running at -30°C		6.2
Brandt UB340 NU		1.7

[10] See http://labs21.lbl.gov/wiki/equipment/index.php/Help:Contents#Usage. If you click on a particular item of equipment you can see the data they collate, e.g. for an oven: http://labs21.lbl.gov/wiki/equipment/index.php/National_Appliance_Co_NAPCO.

[11] Grateful thanks to Jo Hossell of the University of York for permission to publish this data.

Table 2.3: Measured Energy Consumption of -80 Freezers at the University of Newcastle[12]

Brand/model	Capacity (L)	kWh over 24 hour period
Therma Forma model 771		74.2
No name		31.8
Sanyo MDF-U70V	700L	30.7
Sanyo MDFU5086WBT vertical		28.6
Not specified		28.3
Sanyo UDF U50V	520L	27.8
Upright freezer		27.7
Not specified		27.5
Unkown	725L	26.9
New Brunswick	570L	25.2
Sanyo MDF 592		25.1
Not specified		24.7
Sanyo MDF-592		24.6
No name - chest	large	24.0
Swan Dual compressor		23.6
FORMA Scientific - upright	570 litre	23.5
Swan Refrigeration - chest	725 litre	23.3
Swan Dual Compressor		23.3
Swan Dual compressor		23.1
Revco		22.7
Swan Dual compressor		22.5
Lab Impex Research		22.4
Sanyo ultra low		22.2
Sanyo MDF-U570		22.1
Not specified		21.5
NUAIRE Thermal control status		21.0
Sanyo ultra low		20.8
Upright freezer		20.8
Illshun DF8517	570	20.3
SANYO MDF-592		19.9
Gallenkemp Super cold		19.6
FORMA SCIENTIFIC 925		18.7
Lab Impax Research	570	18.3
FORMA Scientific - chest	Approx 750-850L	17.1
No name- chest		16.8
Gallenkamp supercold 85-chest		15.8
New Brunswick - upright	535 litre	13.7
New Brunswick C660-86 chest		12.6
New Brunswick Green	570	11.8
New Brunswick Green	570	11.5
New Brunswick U101	101	6.8

[12] Grateful thanks to Cara Tabaku, formerly of the University of Newcastle, for permission to publish this data.

Scientemp -80°C running at -30°C		6.2
Brandt UB340 NU		1.7

Table 2.4: Measured Energy Consumption of Other Lab Equipment at University of York[13]

Equipment type	Brand/model	Measured average energy consumption (Wh)	kWh over 24 hour period
Biological Safety Cabinet	Trimat 2 (Ducted)	440	10.6
Biological Safety Cabinet	ESCO ACZ 4D1 (recirculating)	330	7.9
Centrifuge	Lge Bench Centrifuge	14	0.4
Centrifuge	Small Centrifuge	6	0.1
Cryostat	Cryostat	643	15.4
Drying cabinet	Drying cabinet (small 600W)	666	16.0
Drying Cabinet	Small 600W drying cabinet	188	4.5
Fridge	standard under worktop size	14	0.3
Fridge	Scandinavia 4°C - freestanding	24	0.6
Fridge	Wooden Fridge	56	1.3
Fridge	LEC (TO290) L6046W	106	2.5
Misc.	-20°C Digitiser	75	1.8
Misc.	Water Purifier	10	0.2
Misc.	Gas Scrubber	114	2.7
Water bath	Boiling water bath	2024	48.6
Water Bath	Boiling water bath	801	19.2
Water bath	60°C bath	152	3.6
Water heater	Kettle	47	1.1
Growth cabinets	Percival AR32L (a)	1100	26.4
Growth cabinets	Sanyo MLR351 (b)	890	21.4
Growth cabinets	Sanyo Fitotron (c)	860	20.6
Growth cabinets	Conviron (d)	3870	92.9
Growth cabinets	Percival Scientific AR75L (e)	1520	36.5
Growth cabinets	Sanyo SGC065 (f)	2590	62.2
Growth cabinets	Snijders 1750 (g)	2760	66.2

(a) run at full lights 8 hours, 20°C 65%rH, off, 16 hours, 17°C, 60%rH
(b) full, 8hrs, 22°C, off, 16, 17°C
(c) run at full lights 8 hours, 20°C 65%rH, off, 16 hours, 17°C, 60%rH
(d) run at full lights 8 hours, 20°C 65%rH, off, 16 hours, 17°C, 60%rH
(e) run at full lights 8 hours, 20°C 65%rH, off, 16 hours, 17°C, 60%rH
(f) run at full lights 8 hours, 20°C 65%rH, off, 16 hours, 17°C, 60%rH
(g) Full Lights (16 Hours @Day/8 Hours @night temps)

[13] Grateful thanks to Jo Hossell of the University of York for permission to publish this data.

Appendix 3– Key Data for Equipment

The sector framework agreement for purchases of laboratory equipment – for which the London Universities Purchasing Consortium is the lead body - provides a useful basis for identifying relevant equipment types. The table below provides some relevant information for these, grouped in terms of their energy consumption characteristics. It is a work in progress, and we welcome suggestions as to how it can be improved, and information gaps filled.

Table 3.1: Equipment Classification and Key Data

Equipment Type	LUPC Category/Lot	Energy Classification [14]	WLC Life (years)	Comments
Cryogenic Conservation Vessels	Environmental Storage	A		
Cryostats	Environmental Storage	A		
Freezers -20oC: upright, under bench and chest	Environmental Storage	A	15?	
Freezers -40oC upright, under bench and chest	Environmental Storage	A	15?	
Ice Maker	Environmental Storage	A	15/	
Laboratory Refrigerator +4oC	Environmental Storage	A	15?	
Liquid Nitrogen Dewars	Environmental Storage	A	15?	
Ultra Low Temperature Freezer	Environmental Storage	A	15?	
Floor-Standing Autoclave - Front Loader	Safety	A/B		
Floor-Standing Autoclave - Top Loader	Safety	A/B		
Centrifugal evaporator	Centrifuges	B	10?	
Centrifuge - low speed / non-refrigerated	Centrifuges	B	10?	
Centrifuge - Low-speed/ refrigerated	Centrifuges	B	10?	
Centrifuge - Medium speed Refrigerated	Centrifuges	B	10?	
Centrifuge - Microfuge Non-Refrigerated	Centrifuges	B	10?	
Centrifuge - Refrigerated Microfuge	Centrifuges	B	10?	

[14] See page 5 of this document for definitions of A,B,C,D

Circulators (cooled)	Environmental Control	B		
Circulators (heated)	Environmental Control	B		
DriBlock Heaters	Environmental Control	B		
Heating Mantles	Environmental Control	B	10?	
Hotplates	Environmental Control	B	10?	
Hybridisation Ovens	Environmental Control	B	20?	
Incubator CO2	Environmental Control	B	15?	
Incubator Shaking	Environmental Control	B	15?	
Incubator Standard	Environmental Control	B	15?	
Incubator Sub-Ambient	Environmental Control	B	15?	
Ovens	Environmental Control	B	20?	
Ovens, Vacuum	Environmental Control	B	20?	
Shakers (benchtop)	Environmental Control	B	15?	
Thermal cycler	Environmental Control	B	10?	
Water Baths	Environmental Control	B	10?	
Glass Washing	General	B	15?	
Pumps, peristaltic	General	B		
Pumps, vacuum	General	B		
Rotary Evaporators	General	B		
Stirrers	General	B		
Water Purification	General	B		
Small Autoclaves - Bench Top	Safety	B		
Furnaces	Environmental Control	C		
Colony Counters	Measurement	C		
Colorimeters	Measurement	C		
Flame Photometers	Measurement	C		
Fluorimeters	Measurement	C		

Freeze Dryer	Environmental Control	C		
Spectrophotometer (UV & Vis)	Measurement	C		
Fume Cupboard (non-ducted)	Safety	C		
Safety Cabinet Class 1	Safety	C		
Safety Cabinet Class 2	Safety	C		
Electrophoresis Blotters & Dryers	General	D		
Electrophoresis Gel Tanks & Gel Units	General	D		
Electrophoresis Power Packs	General	D		
Gel Documentation system	General	D		
Gel Dryer (vacuum)	General	D		
Inverted Microscopes	General	D		
Mixers (vortex)	General	D		
Standard Microscopes	General	D		
Stero Microscpoes	General	D		
Inverted Microscopes	General	D		
Balances	Measurement	D		
Chart Recorders	Measurement	D		
Chloride Meters	Measurement	D		
Conductivity Meters	Measurement	D		
Dissolved Oxygen Meters	Measurement	D		
Melting Point Apparatus	Measurement	D		
Microplate reader	Measurement	D		
pH Meters	Measurement	D		
Thermohygrometers	Measurement	D		