Financial Incentives for Energy Efficiency at the University of Cambridge - RECSO/SusteIT Case Number 3

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Key Points

This case study examines the background, aims and working of the Electricity Incentive Scheme (EIS) that Cambridge University implemented in 2008/09 and has since developed. The Scheme encourages consumers of electricity across the University to maximise their energy efficiency through a system of financial incentives (both rewards and penalties) at a departmental level. It thus achieves the benefits of fully devolved energy budgets without the administrative and managerial implications that this could have involved. Some key features are:

- Revenue-neutrality so that research, teaching and administrative units bear the risks/rewards rather than the central administration;
- An estimated £820,000 of energy savings arising from the Scheme in its first year;
- Targets – which were initially based on 3% above 2008/09 budgets for each unit – are progressively tightened over time.
- Exemptions for new buildings (their first 3 years) and for centralised computing services.
- Feedback suggests that most units have achieved savings through improved housekeeping without too much difficulty. Savings may be harder to achieve in future when all the low-hanging fruit opportunities have been identified.
- The scheme has been made possible by an extensive sub-metering infrastructure.

1. Background

Energy efficiency is more likely to be achieved when users have financial incentives to implement measures. There are two broad administrative mechanisms for achieving this with regard to higher education organisational units such as schools or departments – devolving energy budgets to them, or providing rebates or penalties based on their performance compared with a baseline. The latter has the potential advantage of providing a financial incentive to encourage users to look for savings, whilst avoiding some of the administrative burden of devolved budgeting. This document describes the operation of a scheme of this kind - known as the Electricity Incentive Scheme (EIS) - at the University of Cambridge.

The Scheme began in August 2008 with the approval of the University's Resources Management Committee (RMC), a high-level group containing all Pro Vice-Chancellors and Heads of School. It was proposed by the then PVC for Planning and Resources, Professor Tony Minson, who was increasingly concerned about the rapid increase in the University's annual non-residential energy costs from £4 million to £14 million over the previous decade, despite energy-saving actions by Estates Management and others. This concern was prompted both by financial impacts and because of environmental drivers such as the proposed CRC Energy Efficiency Scheme and the University's own environmental targets. There were some obvious explanations, including rising energy prices and the construction of a number of state-of-the-art scientific research facilities. However, Professor Minson believed that further efficiencies could be possible if users had more financial incentive to take action, and the EIS was designed to provide this. It is administered by Estates Management, specifically by the University's Energy Manager, Paul Hasley.

2. Design of the EIS

The Scheme applies to the University's core 150 research, teaching and administration units (i.e. it excludes the colleges, and associated entities such as Cambridge University Press). These occupy over 300 buildings, most of which accommodate two or more units within them. The majority of these units are academic or administrative departments within the University's 6 Schools - Clinical Medicine, Arts and Humanities, Humanities and Social Sciences, Physical Sciences, Biological Sciences, and Technology. New buildings are excluded from the scheme for the first three years of their operation, on the grounds that their consumption can often be anomalously high in this period due to teething problems.

An extensive sub-metering infrastructure (see Appendix 2) provides data on the energy consumption of each building. This is then apportioned between the units occupying that building, based on their relative proportions of use of the total gross floor area. At the start of each year an annual energy consumption target is set for each unit (see

below for details of how this is calculated). At the end of the year each unit's over- or under-consumption compared to its target is calculated, and it either receives a payment from the centre for each kWh by which it is below this target, or has to pay a penalty charge for each kWh by which it exceeds it. The price per kWh is the same in both cases, and is based on the average price paid for electricity by the University across all of its energy supply contracts. Quarterly reports on actual consumption per unit are generated to help them to monitor their own performance through the year, and individual heads of units can also access the central databases whenever they wish to ascertain their own consumption to date.

The system means that each unit is effectively in the same position, financially, as it would be if energy budgets were fully devolved. In theory, the Scheme should also be revenue-neutral, avoiding any criticism that it is simply a covert internal tax on departments. If there were (say) a net saving by units (i.e. on average they saved more energy than predicted in their budgets), then although there would in total be a net cash outflow from the centre to the units, this would be exactly counter-balanced by the corresponding saving that the centre would make on the University's energy suppliers' bills. This means that the eventual charge borne by the centre must always be equal to the total amount budgeted at the start of the year, so that the risk and rewards of consumption differing from budget will always be absorbed by the units rather than by the centre.

In practice the correspondence is unlikely to be as arithmetically precise as this for several reasons, e.g. timing differences in different supply contracts and suppliers' invoices; differences in VAT status between different units; and possible temporary gaps in the system if meters or metering communications fail and consumption has to be estimated, or if the Scheme is deliberately adjusted so that it does not follow this basic model. An example of the latter occurred in 2009/10 (the 2nd year of the Scheme) when the RMC decided that although overall the Scheme had clearly been successful in its first year, there were still a few units which had not recognized and responded appropriately to the signals and which were therefore still exceeding their budgets and simply absorbing the penalties. To enhance the incentive effect, the amounts of the penalties to be paid to the centre by under-performing (excess-consuming) units were therefore doubled. Half of this 'fine' was to be returned to the centre to cover the cost of the excess usage while the other half would pooled in a fund to be distributed proportionally to units making savings. However, this was only a temporary policy and has been discontinued as from 2011/12, as it was considered to be an unnecessary complication.

3. Application and Experience

It had initially been suggested that the unit-level energy targets for the first year of the EIS (2008/09) be set at a significantly more ambitious (i.e. lower) level than had been achieved in recent years, in order to encourage movement towards the target the

University had set in its Carbon Management Plan of a reduction in emissions by 2020 of at least 34% from 2005 levels. However, it was eventually decided that this could jeopardise the success of the Scheme and that in its early years it would be pragmatic to set the targets at more easily achievable levels.

It was eventually decided to set the 2008/09 budgets at 3% over the levels that each unit had actually achieved in 2006/07 (since this was the most recent year for which the results were known at the time the targets were set). This still represented a significant reduction of approximately 5% as compared with what might otherwise have been expected, on the basis of an underlying increase of 4% per annum from 2006/07 to 2008/09. Despite this, most units managed not only to meet but to improve on their budgets, and there was an overall net saving compared to budget of £144,188 (see Figure 1).

Figure 1: Electricity Consumption – Actual Performance Summary for 2008/09 classified by School, in '000 kWh

	Cumulative Actual				Target for the Year	Variance for the year		Actual Transfer Value
School	**Qtr 1**	**Qtr 2**	**Qtr 3**	**Qtr 4**				
Arts & Humanities	452	996	1,490	1,973	2,130	157 kWh	*7.37 %*	£17,741
Biological Science	8,037	16,722	25,013	33,218	34,018	800 kWh	*2.35 %*	£90,400
Clinical Medicine	3,761	7,042	10,469	14,129	14,639	510 kWh	*3.48 %*	£57,630
Humanities & Social Sciences	985	2,035	3,067	4,109	4,258	149 kWh	*3.50 %*	£16,837
Physical Science	6,992	14,017	20,974	27,798	27,709	- 89 kWh	*- 0.32 %*	£(10,057)
Technology	3,647	7,302	10,984	14,683	14,358	- 325 kWh	*- 2.24 %*	£(36,725)
Library	1,355	2,647	3,931	5,276	5,562	286 kWh	*5.14 %*	£32,318
Central administration	601	1,256	1,904	2,519	2,427	- 92 kWh	*- 3.79 %*	£(10,396)
Other administration	1,735	3,552	5,270	7,021	6,901	- 120 kWh	*- 1.74 %*	£(13,560)
Totals	*27,565*	*55,569*	*83,102*	*110,726*	*112,002*	*1,276 kWh*	*1.14%*	*£144,188*

Notes:-

- the amounts of kWh stated above have been rounded to the nearest '000 kWh
- the transfer values listed in the final column are based on a transfer price of 11.3 pence per kWh.

This net saving of £144,188 comprised a total of £215,000 (rounded) favourable variances by 4 Schools plus the University Library, and a total of £71,000 adverse variances by the other 2 schools plus the central administration and others. The latter were charged with this £71,000 (in practice this meant that this amount was deducted from their budgets for discretionary spending in 2009/10), £215,000 was distributed amongst the over-performers, and the University benefitted at the centre from actual energy bills which were £144,000 less than had been budgeted. On the assumption that without the Scheme the University's consumption would have continued to increase at 4%, this implied an overall saving of nearly £700,000 (i.e. 5% of its total energy bill of approximately £14 million) which was realized at the centre, in addition to the savings realized by those units which had done better than their budgets (see Section 4 below). Informal feedback from the units suggested that most of them had not found it too difficult to achieve this through improved housekeeping.

The amounts of the rewards and penalties were fairly modest in absolute terms compared to most units' total spending. However, since most of this is committed on fixed costs such as staff pay which cannot easily be changed, they made a useful contribution to discretionary spending which might not otherwise have been possible, e.g. for extra conference attendance. At least as significantly, the results were published internally in the form of a 'league table' of winners and losers, which had a motivational effect over and above the monetary amounts involved. The Department of Engineering in particular was embarrassed to find that it had exceeded its target by an amount which was significant in relation to the other gains and losses shown in the league table, particularly since it was active in several energy efficiency-related research projects. This prompted it to review its activities to identify what actions it might take to improve the situation, and these are described in Appendix 1.

Following the success of the Scheme in 2008/09, targets were set for 2009/10 and then 2010/11 on the rather more ambitious basis of the average of the target and the actual consumption for the previous year, plus an uplift of 2% (which is half the rate of growth historically). Targets for 2011/12 and future years will be set at the level of the actual usage in 2009/10, after allowing for the impact on consumption of new academic activities.

It has been found necessary to accept some exceptions from the EIS. For example, new buildings are excluded for their first 3 years, since experience shows that it can take up to this length of time to fill them with occupants, projects and equipment, and until a steady state has been reached it is not possible to identify a reasonable base-line against which to set energy targets. The RMC also had to consider an appeal by the University's Computing Service on the grounds that the (considerable) energy consumption of its data centres and server rooms is outside its control since it is a function of the number of services that it provides to the rest of the University and the level of demand for them, and any restriction on this would be unacceptable to users.

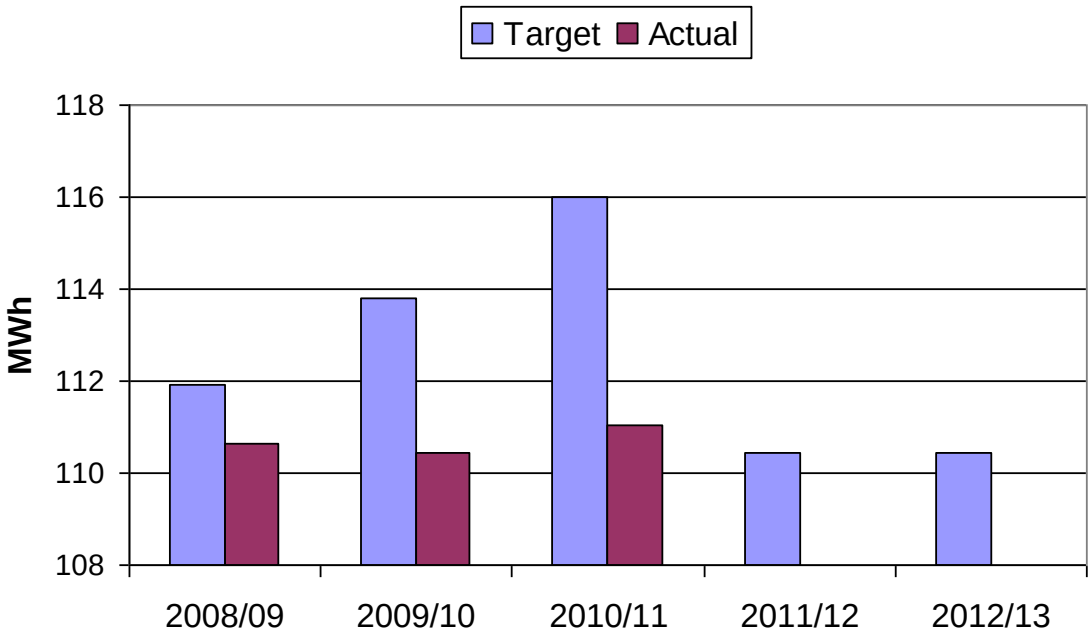
The RMC considered this appeal and eventually decided to accept this argument and to exempt the Computing Service from the EIS. It has also been faced with a couple of further 'hard cases' where units have argued that increased energy usage is justified by increased activities, and has decided that where appropriate an allowance will have to be made within the Scheme for 'new academic activities'. However this is a recent development and has not yet been tested in practice – at the time of writing, units have been invited to put forward examples of planned activities which they consider are likely to require consideration for this reason.

4. Results To Date

The RMC is very satisfied with what the EIS has achieved to date, and plans to continue with this approach. Paul Hasley estimates that in its first year (2008/09) the University realised financial savings totalling £820,000, representing savings in carbon emissions of 3,582 tonnes. This was made up of a saving of £676,000 realised at the centre as a result of achieving the EIS targets compared with the 'business as usual' consumption that would otherwise have been expected, plus a further net saving of £144,000 realised by those units which over-achieved compared to their targets (as indicated in Figure 1 above).

Improvements in efficiency have been continued since then, and the effect is clearly apparent in Figure 2 which shows total consumption of 111 MWh in 2010/11, which despite the University's continuing expansion is only fractionally up on 2008/09.

Figure 2: Actual and Targeted Consumption for the University



5. Future Plans

From 1.8.11 the EIS has been supplemented by a separate carbon levy of 1 pence per kWh. This represents the approximate average cost of the University's liabilities under the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme, which are around £1 million per annum in total, so the effect is that the cost of the CRC is being passed on to the energy-consuming units. Although it is expected that any small future variances in the University's CRC levy will be absorbed centrally, if it were to increase significantly then the RMC would probably be asked to re-consider the amounts to be charged to the units.

The new levy will be much more financially significant and attention-grabbing than the EIS, since it is effectively a gross amount rather than a net amount of actual minus budgeted spend. For example, the School of Biological Science is by its nature one of the heaviest energy consumers in the University, and in 2008/09 its annual budget under the EIS had been set on the usual formula at 34.0 million kWh. Its actual consumption for the year was 33.2 million kWh, i.e. a saving of 800,000 kWh, so at the end of the year it received a reward of £90,400 (at the standard cost in that year of 11.3 pence per kWh). However if the carbon levy had also been running then, the School would also have received an additional charge of £332,000 (33.2 million kWh @ 1 pence each), considerably overshadowing the EIS rebate in scale.

Paul Hasley is also planning to develop the software systems further to make them easier for users to access the information on their units' performance in a user-friendly format. He is also looking for ways to improve the resilience of the metering communications technology. Data is communicated to the central database via the University's Building Management System, but this has sometimes proved problematic when data has been blocked by internal firewalls between different parts of the system.

6. Discussion

The attraction of the EIS is that it operates as a relatively simple overlay on top of existing financial management systems and appears to offer the main benefits of devolved budgets without their potential disadvantages (actual or perceived). These could include an increase in administrative load on those running the budgeting system, an additional and unwelcome financial management burden on heads of organisational units, and a loss of control by the centre. The scheme also insulates units from energy price fluctuations in a way that full devolved budgeting system would not. The league table aspect of the scheme also adds the motivational effect of peer group comparison to the financial driver.

However, now that the EIS is through its initial honeymoon period, some challenges may need to be addressed. The targets have been relatively relaxed so far, and in the early years most units have not found it too difficult to identify 'low-hanging fruit'

improvements so they could meet (and usually improve on) their EIS targets. However further improvements may become more difficult to find, even without the more stringent targets which are currently in prospect, and it is not inconceivable that the EIS could meet more internal opposition. There could also be a risk of gaming behaviour in future by units trying to meet their targets, particularly if continued increases in global energy prices increase the financial incentive effect.

There could also be questions about the 'one size fits all' nature of the targets. Over time different units will expand (or contract) at different rates and therefore have different needs for energy, and arguments are likely that the EIS target for each unit should reflect its own specific consumption drivers – fundamentally, the volume of research it is conducting and the number of students it is teaching. As an example, one unit pointed out that they were currently running a project which if successful would help to develop more efficient turbine blades for jet engines, which when scaled up across all the aircraft on which the blades might be used in future would generate substantial energy savings and reductions in carbon emissions globally. However, this research required periodic testing in the unit's own wind-tunnel, and this was extremely energy-intensive which made it more difficult to meet its EIS target. From a financial perspective this can be seen as simply an unexceptional case of an increased resource cost being justified by increased revenues, but the league table aspect of the EIS could make it appear that the unit's performance was deteriorating, with reputational implications. It has been pointed out that it would be paradoxical if units were to be penalised on environmental grounds for activities which could potentially have a substantial net environmental benefit.

The exemption of new buildings from the scheme for the first three years could also create a risk of moral hazard if this meant that the occupants of a new building had a perverse incentive to take little action to optimize their energy efficiency during this period, in order to have a more favourable baseline against which to measure improvements in the fourth and subsequent years.

Appendix 1 - Impact on the Department of Engineering

Engineering is the largest department in the University of Cambridge. It also had one of the highest bills from the Electricity Incentive Scheme in its first year, at over £36,000. Although this was largely related to an increase in energy-intensive engine research, it nonetheless attracted senior management attention as a potentially embarrassing disconnect with the Department's high level of sustainability-related teaching and research (e.g. to develop more energy-efficient engines). The Department therefore set up two committees, on energy and on sustainability respectively, to identify and implement improvement opportunities.

IT energy was identified as a key target with the main response being a new server room, financed in part by the University's Salix fund (see SusteIT Briefing Paper 2). This has energy-efficient servers; separation of cooling and (hot) exhaust air streams (which reduces mixing, a major source of inefficiency); and evaporative cooling. The latter has long been used in hot dry climates but is unusual in the UK, especially in server rooms. It cools inlet air by drawing it over moist pads, causing evaporation (and a consequent loss of energy from the air itself). The only energy which is used is for fans. As a result the facility has a Power Usage Effectiveness (PUE) Index of 1.1, one of the lowest in the sector (see SusteIT Briefing Paper 5). The technology does have some potential problems such as increased humidity levels (though generally within the tolerance of modern computing equipment); filtration (and a related inspection and maintenance programme); and significant amounts of space occupied. However these are outweighed by the benefits which include an annual reduction of 200 tonnes of carbon emissions and £40,000 of costs, despite a 50% increase in computing power. In the summer of 2011 ambient conditions exceeded 30C, with high humidity levels, but the temperature in the cold aisle did not exceed 25C. A number of meters have also been installed in the facility, including on individual racks. These allow costs to be calculated and passed back to research groups, thereby increasing their incentive to use computing power frugally.

David Green, Superintendent of the Engineering Workshops, notes that: "We've taken a number of measures to reduce energy and associated carbon in recent years, with evaporative cooling being the most successful. I don't think that this would have happened to the same degree, or as quickly, without the stimulus of the Electricity Incentive Scheme. And the driver isn't just money, helpful though that is, it's also about wanting to do well in a very visible 'league table' within the University."

Appendix 2 – Energy Accounting and Metering

Cambridge is similar to many other universities in its approach to energy accounting. Energy suppliers' bills are paid from a central budget which is managed by Planning and Resource Allocation, together with Estates Management. These costs are then aggregated with those of other utilities and maintenance to create a total 'space cost' for the University which is then allocated between the various schools and departments in proportion to the floor space occupied, weighted to reflect the differing energy demands of different types of activity (e.g. laboratories and data centres are weighted much more heavily than lecture theatres and offices). The aggregation of energy costs with other items, and their subsequent allocation on a basis which is unrelated to actual consumption, means that users lack information on their own use. There is also no financial incentive for them to become more efficient because the space charge they pay will be unaffected by it.

Since 2000 the University has installed an increasing number of energy sub-meters, with a policy of having at least one electricity meter in every building. In a few buildings where consumption is high there might be multiple meters for different parts of the building, though these are the exception. Currently there are about 350 electricity meters in total in the 300 buildings occupied by the 150 organisational units included in the EIS (several units occupy space in more than one building). Data from the meters is then transmitted to a central database in the energy department which runs the Scheme. Initially this was over telephone lines but more recently has been over Ethernet, via its Building Management System. The software used to run the system is a combination of various systems including Energy Manager by Systems Link.

However, the data that they have generated has been used by Estates Management in order to inform their management of buildings and decisions on improvement projects, rather than for costing or user awareness. The emphasis has also been on metering electricity in priority to other utilities such as gas and water. This is technically more straightforward since electricity meters tend to be more robust and therefore less problematic in operation than those for gas or water. Also, the information generated could often be related more directly to individual buildings as electricity wiring circuits are specific to them, whereas the gas measured by a gas meter might be used for heating a group of adjacent buildings.