**Title**:

Energy Efficiency Interventions in UK Higher Education Institutions

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**Abstract**:

This paper provides an insight into energy efficiency interventions studies, focusing on issues arising in UK higher education institutions (HEIs) in particular. Based on a review of the context for energy efficiency and carbon reduction programmes in the UK and the trends in higher education sector, existing external and internal policies and initiatives and their relevant issues are extensively discussed. To explore the efficacy of some internal intervention strategies, such as technical, non-technical and management interventions, a survey was conducted among UK higher education institutions between February and April 2008. Consultation responses show that there are a relatively high percentage of institutions (83%) that have embarked on both technical and non-technical initiatives, which is a demonstration to the joined-up approach in such area. Major barriers for intervention studies are also identified, including lack of methodology, non-clarity of energy demand and consumption issues, difficulty in establishing assessment boundaries, problems with regards to indices and their effectiveness and so on. Besides establishing clear targets for carbon reductions within the sector, it is concluded that it is important to develop systems for effectively measuring and evaluating the impact of different policies, regulations and schemes in the future as the first step to explore.

**Key words:** Energy Efficiency Interventions, Higher Education Institutions (HEIs), Carbon Reductions

## 1. Introduction

Energy Efficiency intervention studies have huge benefits to society and to different energy sectors in the economy. They enable a clear understanding of the impacts of current programmes and encourage a more systematic use of knowledge especially for evidence-based policy. Additionally, they provide impetus for the development of constructive practices that improve energy efficiency and carbon emissions abatement in any sector. At a practical level, intervention studies aim to ascertain the extent to which energy consumption patterns have changed and the instruments used to achieve these changes. They look at the efficiency of the different instruments in achieving their set objectives. Intervention studies offer practical results as well as theoretical benefits especially in clarifying assumptions underlying interventions.

This paper contains a review of the state of affairs in the Higher Education Institutions (HEIs) with regards to internally and externally driven energy efficiency and carbon reduction initiatives. It forms part of a bigger review on energy demand patterns in HEIs and seeks to:

A1. Identify and collate data from known datasets and new sources on energy consumption in the higher education sector

A2. Establish a historical trend in higher education energy consumption patterns

A3. Identify the existing practices in HEIs in response to subsisting carbon emissions and energy consumption reduction regulations, policies and programmes

A4. Establish the levels of efficacy of various energy efficiency and carbon reduction initiatives in the subsectors

A5. Working with and refining the existing data sets as input to the proposed non-domestic stock model

A6. Flag up issues impeding the success of carbon management and energy reduction programs in the subsectors

A7. Identify issues for the future in energy consumption and carbon emissions reduction within the subsectors

This review focuses mainly on A3, A4, A6 and A7. Aims A1-A2 have already been treated in an article in the Energy Policy journal of August 2008 (Ward *et al.* 2008).

A review of energy efficiency initiatives in higher education institutions or any other sectors would require a general understanding of the social, economic, political and environmental context within which these initiatives have been introduced and are expected to operate. This review therefore starts with a brief background of the context for energy efficiency and carbon emissions abatement programmes in the United Kingdom as well as the trends in UK higher education sector (Section 2). Section 3 presents an overview of existing external and internal policies and initiatives as well as factors exerting influences towards carbon emissions reduction in higher education institutions. Other issues discussed include insights from intervention studies (Section 4) and issues regarding future work (Section 5 and Section 6).

## 2. Background

### 2.1 The Context for Energy Efficiency and Carbon Reductions

There is scientific consensus that global warming is real and is largely caused by human influence on the environment (IPCC 2001). The Stern Review report suggests that a 25% reduction below current levels of emission is required in order to stabilize global $CO_2$ concentrations at levels that will not have very adverse impacts (Stern Review 2006).

Challenges to energy security occasioned by resource depletion and the resultant increases in energy costs have also underpinned the move towards reduction in energy consumption. With speculations rife that 'Hubbert Peak' of global oil production will be reached within the next 20 years (Hirsch *et al.* 2005), it is anticipated that there will be significant rises in oil prices led by the increased scarcity of petroleum supply. 'Peak Oil' is the point in time when half of the world's oil reserves would have been used and when scarcity sets in with the rush for supply security fuelling price increases. The gradual slow down in the rate of oil production (see EIA 2008, BP 2008), drops in proved oil reserves, increased number of net oil importers among previously net producers and the increasing levels of investment by big oil firms in renewable technologies are seen as symbols of the reality of approaching or having indeed crossed the peak point.

Similar high price increases have expectedly been recorded in the electricity supply sector. For instance, between 2007 and 2008, there have been double digit percentage increases in electricity

supply tariffs in the UK and speculations are rife that more increases may be recorded in electricity tariffs in the not-too-distant future. This trend is a very bad news for stakeholders in all sectors and individual households alike. Society is thus faced with two difficulties of not having enough supplies of energy at affordable prices for continued sustenance and growth and of causing irrevocable damage to the environment by using up as much energy as it may produce. It is under these contexts that policies and programmes have been introduced to encourage reduction in energy consumption and the associated carbon emissions.

The UK higher education sector experiences the same dilemma as it strives for sustenance and growth. In fact, situation in this sector can be worse as the UK higher education and education-related services are considered to be one of the fastest growing export earners with significant economic and environmental impacts at local, regional and national levels (Universities UK 2006).

Following the Robbins (1963) and Dearing (National Committee of Enquiry into Higher Education 1997) committee reports, there was a broadening of range of subjects taught in HEIs as well as a widening of the cohort of students receiving training in HEIs. Higher education in the UK has been undergoing transformation from a 'selective system' to a 'mass system' with a goal to widen participation, diversity and access (AUA 2004). There has also been increased emphasis on applied research and technology transfer, especially in areas that are likely to generate research income to support UK global competitiveness. These structural changes have led to sharp increases in the amount of students enrolled in higher education in the UK and the level of research activities conducted in HEIs across the UK with several ramifications. For example, between 1995 and 2005 alone, there was a 33% increase in higher education student enrolment (Universities UK 2006). The total number of student enrolment in higher education in the UK currently stands at about 2.5 million (HESA 2008). Analysis of the Estate Management Statistics data (Sheffield University 2007) shows there are significant increases in higher education institution estates sizes, which are about 6% above 2001 levels. These have undoubtedly caused increases in the demand for energy with considerable environmental costs.

The rapid expansion of the higher education sector means that in many UK regions, the higher education institutions and in particular the universities have become large employers and major

poles of economic and social growth. Their traditional roles of 'judges of society' seem to have been expanded by including agents of regional development (Karran 2007). As a result, there are increased expectations that universities and other institutes of HEIs in the UK would provide intellectual and practical leadership on how sustainable societies can be achieved. A major disadvantage of this rapid expansion is that it leads to a significant decline (37%) in the unit of resources available to institutions per student (AUA 2004). Hence there is a need for efficient allocation, management and utilisation of resources.

Schools, colleges and universities are thought to comprise more than 5% of all the buildings in the UK. The UK public sector accounts for about 8% of UK total carbon dioxide emissions and the education sector is said to represent about 14% of this figure (BERR 2007). Recent studies show that energy use in school buildings alone may be responsible for as much as 5Mt of $CO_2$ annually (DEFRA 2007a). These statistics underscore the need for urgent action towards carbon dioxide emissions reduction in the further education sector.

## 2.2 Key Higher Education Trends

There are many factors jointly affecting energy demand and consumption in the higher education sector, including student and staff numbers, weather conditions, building characteristics and appliances, available fuels and fuel costs, as well as equipment deployed within the buildings for academic business.

Some of the key trends identified by previous studies are:

- Significant increase in student numbers. A 33% increase in student enrolment in the ten year period between 1997 and 2006 and 2% increase between 2005 and 2006 alone (Universities UK 2007) with associated increase in staff numbers.
- Increased volume and complexity of research activities leading to increased demand for energy intensive equipment (HEFCE 2003).
- Significant increases in enrolments in subjects allied to medicine, biological sciences, mathematical sciences, computer science (Universities UK 2007) resulting in increased demand for lab equipment often associated with higher energy and water demands.

- 50% increase in enrolment of postgraduate students between 1997 and 2006 typically representing above 20% of student population (Universities UK 2007) means increased intensity and longer periods of use of facilities and buildings (e.g. 24-hours-operation).
- Diversification of academic activities with increased use of IT and sophisticated equipment in buildings (HEFCE 2003).

Some of the consequences of these changing trends are the increase in energy demand in HEIs. It is believed that the increases over the past years are due to the heating and lighting requirements of the vast estates, reliance on and heavy use of computers and power-hungry research equipment. Ward *et al.* (2008) report that there is about 2.7% increase in energy consumption levels in the higher education sector between 2001 and 2006, which results in about 4.3% increase in direct final energy related emissions in such sector.

Conclusion drawn from the unfolding trends among HEIs is that reduction in energy consumption is a 'must' action for the higher education sector. Taking into account financial, environmental and social benefits, such reduction will save the institutions money, help in reducing the demand for finite fossil fuels and the associated green house gas emissions thus mitigating against harmful climate change, and enhancing the corporate image of the institutions.

### 2.3 Data and Methods

In order to understand the level of carbon emissions abatement initiatives in the higher education sector as well as the efficacy of these programmes, our survey conducted between February and April 2008 was targeted at all higher education institutions in the UK. The survey sought to elicit information about energy efficiency interventions in four areas:

- To identify the existence of and types of carbon reduction initiatives embarked on by the institutions between 2001 and 2007;
- To substantiate the assumption that particular designated strategies in HEIs are more energy intensive than others;
- To identify the range of technical initiatives adopted by institutions, explore the degree of diffusion of such initiatives, and understand the levels of success and savings derived;

- Explore the range of non-technical initiatives adopted by different institutions and look at the levels of set-up costs, levels of success and the savings made.

Even though all UK higher education institutions were the target population, mailing details of energy managers/officers were available for a limited number of institutions. Consequently 80 questionnaires were issued, representing just over 60% of the total amount of institutions. The survey was administered by the University of Sheffield CaRB (Carbon Reduction in Buildings) research team. A closed self-completion questionnaire, which was designed as an excel worksheet with drop down menu options, was used to collect data. The menu options were derived from archive studies of several HEIs annual reports that highlighted energy reduction interventions as well as reports of other initiatives from organizations such as the Carbon Trust. The questionnaire was designed to reduce the time burden for completion by participants while retain sufficient level of detail and accuracy for our assessment. It was assumed that energy managers/officers would have access to all the data required in the questionnaire given that such information was regularly compiled for statutory estates reporting.

The questionnaires were sent via email to identified energy managers/officers or other designated officers in a total of 80 universities and institutes. 23 responses were received. This number represents about 18% of the 131 universities and specialist institutions and general colleges. Although, 23 responses made up 18% of the universities participated, as an absolute number of responses this is still considered small even though the results are statistically significant compared to the whole stock, and therefore it could give slightly misleading results. 17% of these responses were from specialist institutions which make up about 31% of the sector, while 83% were received from universities. The results show that the response rate from the ancient universities was 67%, 29% from ‘plate glass’, 18% for specialist institutes, 17% for ‘redbrick’, and 9% of new universities.

After receiving the completed questionnaires, the data was scrutinized using certain quality control measures such as correlating the questionnaire entries with the information available on the various institutions’ websites as well as with other privately held data. A simple MS Access database was then created to log the information. Statistical results were obtained through MS Excel application functions.

To ascertain the popularity of different initiatives in the higher education sector, the questionnaire required energy managers categorise the technical interventions undertaken into following areas:

- Systems controls installations
- Electric power source changes
- Equipment efficiency improvement measures
- Heat source changes or upgrades
- Insulation projects
- Monitoring initiatives

Questions about non-technical interventions looked at a range of behaviour modification and awareness schemes introduced by the institutions. In both cases, respondents were asked to identify specific programmes adopted and indicate the cost band, level of success achieved and the actual savings made through the implementation.

**3. Energy Efficiency and Carbon Reduction Policies and Initiatives**

The UK government sets out its energy policy goals in the Energy White Paper (DTI 2003) which included: Reduction in carbon emissions, energy supply security, economic competitiveness, and adequate and affordable heating especially for homes. It also sets a target of reducing carbon dioxide emissions by around 60% by 2050.

Stern Review (2006) concludes that three elements of policy are required for an effective global response to the threat of dangerous climate change. These are listed as:

- The pricing of carbon
- Support for innovation and deployment of low carbon technologies
- Removing the barriers to energy efficiency

The Lord Marshall's report (1998) had earlier advocated the balancing of pressures on the environment on business and government without jeopardizing the competitiveness of industries. The idea was to put as much pressure on the energy producers to clean up their processes as on the consumers to reduce their consumption levels. Some schemes such as the Climate Change Levy and the Climate Change Agreement had their origins from this report (ETSU 2001).

The initiatives and policies mentioned above have given impetus to the interventions and developments in carbon abatement and energy reduction programmes in the UK. In the following sections, further information is provided from external and internal perspectives.

### 3.1 External Influences to Change in Energy Consumption Patterns in HEIs

These include taxation and regulatory frameworks such as:

- EU Emissions Trading Scheme (EU-ETS): The emissions trading directive applies to all thermal combustion installations with rated thermal input exceeding 20MW and became effective on 1 January 2005. Under the scheme, participating institutions were issued with permits as well as $CO_2$ emissions allocations for a specified period (2005-2007). Where the amount of allowances is exceeded, the institutions had to purchase more from other participating organizations that had emissions allowances left. Sufficient emissions allowances must be accumulated in order to avoid penalties which are currently set at about €100/t$CO_2$ between 2008 and 2012 (EU 2003). 40 universities participated in the first phase of the scheme and it is anticipated that only about half this number will participate in phase 2 due to changes in the criteria for inclusion (Hopkinson and James 2007). It is important to note that 40 universities that participated in phase 1 recorded significant reductions in emissions compared with their performance prior to the scheme. Furthermore, Hopkinson and James (2007) noted that even though the participating universities exceeded their emissions quota by 5.2% in 2006, it was still a very good demonstration given that the target was based on a 16% reduction in their emissions levels relative to 1999-2002 period.
- Climate Change Levy (CCL): The climate change levy was introduced in 2001 as a tax on delivered energy to non domestic consumers. The aim is to provide an incentive for organizations to improve energy efficiency and reduce green house gas emissions. A parallel programme to the Climate Change Levy is the Climate Change Agreement which encourages energy intensive organizations to set and meet carbon savings targets in return for 80% reductions in Climate Change Levy.

- Part L Building Regulations: Higher education institutions have very large estates. The scale of building-related environmental impacts for new and old buildings makes them an important sector in the battle for carbon dioxide emissions reduction. The new building regulations set more stringent targets for the environmental performance of buildings in the UK. The 2006 version of Building Regulation Part L is designed to achieve an additional 25% improvement in energy efficiency of new buildings in the UK relative to 2002 level (Hopkinson and James 2005).
- Display of Energy Certificates (DECs): This is part of the EU Environmental Performance of Buildings Directive (EPBD) requiring the display of the $CO_2$ emissions based on actual energy consumption of buildings over 1,000m². It also sets targets for the regular inspection of cooling plants. This directive took effect from 1st October 2008 and compelled organizations to regularly monitor their building-related emissions against the benchmarks and building level emissions targets. This directive is likely to affect a whole range of buildings in HEIs (including halls of residence) and will require significant financial and human support for its implementation. Some of the benefits expected from this scheme include improved energy performance information and the potential for performance targeting and benchmarking. In order to meet the deadline, HEIs had to collect metered energy consumption readings in the affected buildings from September 2007.
- Carbon Reduction Commitment (CRC): This is a mandatory 'cap and trade emissions scheme' for all organisations whose mandatory half hourly metered electricity consumption exceeds 6,000MWh per annum or with an annual spend of approximately £500,000. The scheme will require organisations to report direct and indirect emissions annually and will involve the issuance of or allowances to be purchased by the organizations at periodic auctions. When the scheme finally takes off, it is estimated that over 60% of higher education institutions who submit data to the Energy Management Statistics (EMS) would fall into this category. In practice, this scheme will require that participating HEIs monitor all their energy use and set consumption targets to avoid financial penalties that may arise from the need to purchase more emissions credits.

### 3.2 Internal Influences to Energy Efficiency in HEIs

These include influences such as:

- Rising energy costs: With the price of oil rising in 2008, energy costs are affected by this and the utility companies are increasing their prices of energy supplies such as gas and electricity.
- Corporate Social Responsibility (CSR): This is an initiative taking account of their economic, social and environmental impacts, and acting to address the key sustainable development challenges based on their core competences wherever they operate – locally, regionally and internationally.
- Statutory obligations: These are covering internal obligations set by individual HEIs relating to energy suppliers to deliver energy efficiency improvements in their estates as well as various measures including insulation, heating upgrades and renewables.
- Economic competiveness: This is mainly to do with the commercialisation of university research that has been identified as a strategic priority by government, economic development agencies and higher education institutions as a route to increasing economic competitiveness.
- Concerns for the environment: Due to climate change and other environmental issues occurring worldwide, all HEIs in the UK are having environmental policies internally and trying to do their parts in order to reduce their environmental impact.
- Access to capital: In the public sector, access to capital is frequently directly rationed by government with the aim of controlling public borrowing. The assumption is that private sector investment is more productive and that excessive public expenditure will damage economic objectives. If an organisation has insufficient capital through either internal funds or borrowing, energy efficient investments may be prevented from going ahead. In the public sector, additional borrowing may be inhibited by public sector rules. In the private sector, companies may be reluctant borrow due to concerns about the risk of increased gearing. Where internal funds are available, other priorities may take precedence, thereby also preventing the energy efficient investment.

- Corporate image: This is for all HEIs to enhance their corporate image and create an improved corporate image for their University as a 'green university'.

## 4. Insights from Intervention Studies

### 4.1 External Interventions in Higher Education Institutions' Carbon Emissions

Carbon Trust Higher Education Carbon Management (HECM) programme launched in 2005 is one of the initiatives developed to inform and guide organizations towards improved energy efficiency. The programme offers practical technical support, change management support and capacity building to HEIs in order to achieve the objective of carbon emissions reduction and energy efficiency. This improves the profile of energy management in HEIs and provides the energy management group with a framework within which energy savings and carbon reduction programmes can be carried out. In 2008, 68 out of the 106 universities in the UK were working with the Carbon Trust under the HECM scheme to identify and implement carbon saving schemes. One of the major achievements of the participation in the HECM programme is the detailed mapping of the institutions' carbon impacts, which is a key step in any effective carbon emissions reduction programme.

In 2006, the Carbon Trust Enterprises launched a new programme – 'Partnerships for renewables'. It aimed at enabling pubic sector organizations partner private organizations in developing renewable energy projects on public sector land in a bid to drive the uptake of renewable power supply. HEIs are qualified to join the programme.

The Higher Education Funding Council of England (HEFCE) has several initiatives geared towards encouraging HEIs to sustainable development. Many of these initiatives are channelled towards supporting the processes leading to the identification of actions that can lead to a reduction in energy consumption. These include the HEFCE energy management benchmarking software, national report and the management review guide. These initiatives have raised awareness and management profile of energy consumption and provided the framework for statutory compliance for carbon reductions in the higher education sector. One of the HEFCE sponsored programmes is the Higher Education Environmental Performance Improvement project (HEEPI) which was established in 2001. HEEPI runs events to sensitize HEIs on sustainability

issues, organizes green gown awards, conducts building level benchmarking studies and hosts online sustainability assessment resources. The flagship programme, green gowns award, is a coveted award for sustainability in the built environment and is cosponsored by Association of University Director of Estates, British Universities Directors of Finance, Environmental Association for Universities and Colleges and HEFCE. In 2005, HEFCE sustainability in higher education programme was launched to among other things engage with stakeholders to bring about policy synergies on sustainable development. One of the criticisms against the HEFCE initiatives is the 'soft touch approach', which argues that most of the schemes are based on self reporting while lack of independent confirmation of information and there are only limited incentives and penalties for compliance.

Availability of grants reduces the risks of investments in new technologies and increases the rate of uptake of more energy efficient technologies. Salix Finance public sector revolving fund scheme is part of the Environmental Transformation fund established to meet such needs (House of Commons 2008). It provides matching fund loans to public organizations and through its mechanisms encourages the reinvestments of savings in further energy efficiency programmes. The introduction of finance schemes, such as the Salix finance and the Low Carbon Buildings Programme (House of Commons 2008), offer incentives by reducing the risks associated with adoption of new technologies. Records are not immediately available on the number of HEIs that have benefited from these programmes. However, it is believed that a significant number of the improvement projects undertaken by HEIs would benefit from such grants. It is also worth noting that such grant schemes have (when compared to the stock) very small amounts of the funding available.

### 4.2 Internal Interventions in Higher Education Institutions' Carbon Emissions

Among the institutions that participated in the survey, 83% reported embarking on both technical and non-technical initiatives aimed at carbon reductions and energy saving, 13% reported only technical initiatives and 4% reported embarking on no initiatives between 2001 and 2006. Technical initiatives refer to technology based initiatives for energy efficiency and carbon emissions reduction while non-technical initiatives targeted at the same goal though referring to

behaviour modification and structural changes. There are also management interventions which successfully contribute towards HEIs' respective energy management programmes through their direct association with submetering and monitoring of energy consumption.

The relatively high percentage of institutions that have embarked on both technical and non-technical initiatives is a demonstration to the joined-up approach adopted in tackling the issues of energy efficiency and carbon reductions. While this is a welcome development, it masks the impacts of particular programmes and makes it more difficult to ascertain their competitive efficacy. Table 1 shows the result of the questionnaire survey conducted between February and April 2008 which aimed at identifying carbon emissions reductions in HEIs.

Table 1: Higher Education carbon emissions and energy reduction interventions between 2001 and 2007

| Intervention Category | | Proportion of respondents | Cost band | | | Level of success | | | Percentage Savings |
|---|---|---|---|---|---|---|---|---|---|
| | | | <£1K | £1K-£10K | >£10K | Successful | Not Successful | Indeterminate | |
| Controls | Boiler sequence controls | 35% | - | 75% | 25% | 50% | - | 50% | 5% - 22% |
| | Heating controls | 78% | - | 39% | 61% | - | - | - | up to 10% |
| | Lighting controls | 74% | 6% | 59% | 35% | 71% | - | 29% | 10% - 35% |
| | Motor controls | 52% | - | 58% | 42% | 92% | - | 8% | up to 50% |
| | Thermostatic Regulator Valve (TRV) | 48% | 18% | 55% | 27% | 70% | - | 30% | up to 5% |
| | Average | 57% | 12% | 57% | 38% | 71% | | | |
| Electric Power Source | Combined Heat & Power (CHP) | 26% | - | 17% | 83% | 67% | - | 33% | up to 2000tC, 15% reduction in emissions |
| | Photovoltaic system | 26% | - | 17% | 83% | 67% | - | 33% | 1% - 5% |
| | Wind turbine | 4% | - | 100% | - | 100% | - | - | 1% |
| | Green electricity supply | 65% | 13% | 7% | 80% | 80% | - | 20% | up to 30% emissions reduction, 3700tC, saves CCL |
| | Average | 30% | 13% | 35% | 82% | 79% | | | |
| Equipment Efficiency measures | Boiler replacement | 70% | - | 13% | 87% | 94% | - | 6% | 10% - 46% |
| | Heat recovery systems | 48% | 9% | 64% | 27% | 80% | - | 20% | up to 15% |
| | Point of use hot water heaters | 4% | - | 100% | - | - | - | 100% | |
| | Voltage reduction equipment | 4% | - | - | 100% | - | 100% | - | |
| | High efficiency motors | 22% | - | 60% | 40% | 100% | - | - | up to 10% |
| | Lighting upgrades | 78% | 6% | 50% | 44% | 78% | - | 22% | up to 20% |
| | Other efficiency improvements | | - | - | - | - | - | - | |
| | Average | 38% | 8% | 57% | 60% | 88% | | | |
| Heat Source | Combined Heat & Power | 26% | - | 17% | 83% | 67% | - | 33% | up to 2000tC, 15% reduction |

| Intervention Category | | Proportion | Cost band | | | Level of success | | | Percentage Savings |
|---|---|---|---|---|---|---|---|---|---|
| | (CHP) | | | | | | | | in emissions |
| | District Heating supply | 4% | - | - | 100% | 100% | - | - | |
| | Solar thermal system | | - | - | - | - | - | - | |
| | Biomass boiler | | - | - | - | - | - | - | |
| | Geothermal heat source | 13% | - | - | 100% | 67% | - | 33% | |
| | Other | | - | - | - | - | - | - | |
| | Average | 14% | | 17% | 94% | 78% | | | |
| Insulation | Cavity wall insulation | | - | - | - | - | - | - | |
| | Roof insulation | 43% | - | 30% | 70% | 90% | - | 10% | 10% - 36% |
| | Pipe work insulation | 74% | - | 71% | 29% | 94% | - | 6% | 5% - 35% |
| | Other insulation | 17% | - | 25% | 75% | 50% | - | 50% | up to 15% |
| | Partition wall insulation | 4% | - | 100% | 0 | 100% | - | - | |
| | Average | 35% | | 57% | 43% | 84% | | | |
| Monitoring | Sub metering | 91% | - | 48% | 52% | 71% | 7% | 24% | up to 3%, £50K |
| | Building Energy Management Systems (BEMS) | 52% | 17% | 25% | 58% | 58% | 8% | 34% | up to 15% |
| | Other (please specify) | 26% | - | 67% | 33% | 83% | - | 17% | up to 20% |
| | Average | 56% | 17% | 47% | 48% | 71% | | | |
| Non-technical initiatives | Student awareness | 57% | 46% | 46% | 8% | 77% | 8% | 15% | up to 18% |
| | Staff awareness | 74% | 59% | 35% | 6% | 70% | 6% | 23% | up to 7% |
| | Energy champions | 39% | 100% | - | - | 67% | 33% | - | up to 18% |
| | Student competitions | 17% | 75% | 25% | - | 75% | - | 25% | up to 11%, £10K |
| | Reduction in estate size | | - | - | - | - | - | - | |
| | Improvement of space utilization ratios | 26% | 50% | 33% | 17% | 83% | - | 17% | 1% |
| | Green business travel initiatives | 30% | 29% | 29% | 42% | 43% | 14% | 43% | up to 8% |
| | Average | 41% | 60% | 34% | 18% | 69% | | | |

*Source: Building Environments Analysis Unit-School of Architecture, The University of Sheffield interventions survey (February - April 2008)*

### *4.2.1 Technical Interventions*

The survey reveals that the largest aggregate percentage of interventions in HEIs was related to the installation of control systems. However, the single most adopted intervention reported was sub metering, which recorded 91% diffusion among the institutions. Figure 1 shows the distribution of the aggregate percentage adoption of different categories of energy efficiency initiatives.

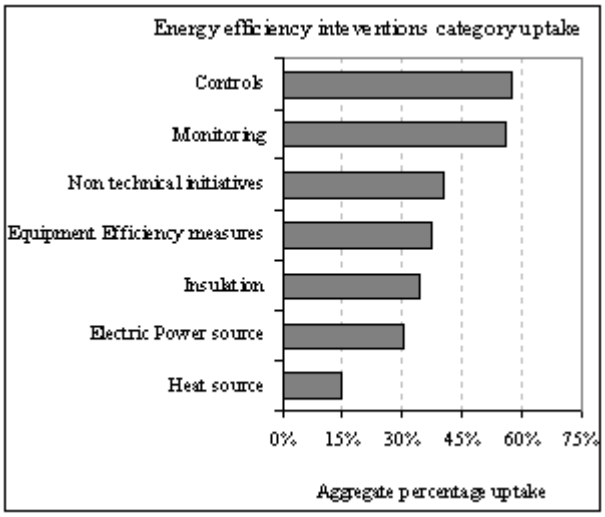


Figure 1: Energy efficiency interventions diffusion patterns

Equipment efficiency improvement initiatives recorded the highest levels of success by leading to between 10% and 46% reductions in energy demand. More specifically, boiler replacements which recorded about 70% uptake were reported as successful by 94% of institutions where they had been installed. Even though very high levels of success have been reported by institutions, equipment efficiency improvement or market transformation schemes are ranked fourth out of seven in the order of popularity of technical interventions in HEIs. The survey also shows that over 50% of such schemes cost more than £10,000 and 48% cost between £1,000 and £10,000.

Insulation interventions recorded the second highest levels of success and are reported to have resulted in some of the highest reductions in energy consumption of between 5% and 35%. Yet insulation ranks fifth out of seven in rate of adoption. It is also interesting to note that 57% of insulation projects were reported to have cost between £1,000 and £10,000 to implement. Given

the rate of success recorded and the relatively low implementation costs, there appears to be a strong case for taking into account fabric insulation as key measure in HEIs.

Switching of electric power source was rated as the joint third most successful initiative for carbon emissions reduction in the sector along with introduction of control systems and monitoring. Green electricity purchasing was adopted by 65% of the respondents while the use of Combined Heat & Power (CHP) plants and Photovoltaic (PV) systems was reported by 26% respectively. The adoption of wind power for electricity was reported by 4% of the respondents. 62% of the power source switching involved implementation costs above £10,000 and 35% between £1,000 and £10,000. Although the uptake of green electricity may be seen as a positive development, only a small proportion (5%) of UK's grid electricity is generated from clean hydro and wind power plants (DEFRA 2007b). The low proportions of 'green' electricity supplies raises concerns that some of the supplies touted as 'green' may not be derived from completely renewable sources. This means that less environmental benefits are actually derived from green purchases than many organizations anticipate. However, through such way, organizations are able to make cost savings due to lower Climate Change Levy charges. Reductions of up to 2000tC per annum or 15% of annual emissions were recorded by some institutions that had installed CHP. Reductions of up to 3700tC per annum and up to 30% of annual emissions were also cited by some institutions as arising from switching to green electricity supplies.

#### *4.2.2 Non-Technical Interventions*

User behaviour modification through education and 'carrot and stick' programmes is considered to be important non-technical interventions. Incentive schemes at St. Andrews and Sheffield Hallam are examples to support programmes with stick and carrot approach. As the cheapest set of carbon emissions reduction interventions, over 60% non-technical initiatives require less than £1,000 for implementation. These include user behaviour modification schemes based on awareness programmes and several 'carrot and stick' schemes. Many HEIs now have regular energy and environment awareness workshops for staff and students. As a result, significant reductions in energy use and costs have been recorded in several schemes, especially in students'

halls of residence, at Sheffield Hallam University, University of St. Andrews and University of East Anglia and so on.

Changing delivery methods through open, e-learning and distance learning programmes have also been presented as avenues for carbon emissions reduction in the higher education sector. However, Roy *et al.* (2004) posit that while these methods of delivery may reduce campus energy consumption, they normally lead to increases in the energy consumed by students in their homes, thus resulting in increases in overall higher education environmental impact.

Green travel initiatives, such as imposing car parking charges, cycle ownership schemes, providing cycle parks and showers, car share clubs and business car pools and collaborations with bus operators to deliver convenient and affordable transport to and from work, have been successfully implemented by many institutions. These initiatives target the downstream sector of higher education and at the same time encourage sustainable energy behaviour among members of the HEIs community.

There are also several student initiatives ongoing in HEIs. The student campaign group 'People and Planet' has provided impetus for shifts in environmental programmes of several institutions. However, it has been noted that many of these programmes appear to focus more on ethical and fair trade issues than actual energy reduction schemes (Hopkinson and James 2005).

#### *4.2.3 Management Interventions*

Significant progress has been recorded with increases in monitoring especially through submetering for energy consumption. Over 90% of respondents in the survey reported some levels of submetering and monitoring of energy consumption in their institution estates. 62% described the schemes as successfully contributing towards their respective energy management programmes. A significant majority of 65% reported submetering and monitoring of energy consumption in all buildings, 30% in over half of the buildings, while 5% in specific buildings only. Since it is difficult to ascertain the exact periods when energy consumption monitoring commenced in these institutions, the high proportion of institutions currently engaged in monitoring can only be viewed as a positive step towards improving the quality of energy information prior to energy saving and carbon reduction action.

Many institutions have adopted 'Smart' fuel purchasing strategies, involving tariff monitoring and switching in order to reduce energy costs. However, these strategies are aimed at reducing fuel costs rather than achieving reductions in energy consumption.

Several green procurement schemes have also been adopted by HEIs to address the downstream sector of HE energy consumption. These strategies aim to exert influence on the wider society which is increasingly falling under the scope of operations of higher education institutions. These schemes cover areas such as construction, stationary and catering.

The adoption of formal quality measures like ISO 14001 has also been identified as potent strategies for environmental quality assurance in HEIs. Unfortunately, very few UK universities are signed up to formal certification schemes that offer campus wide environmental certification. The strength in such schemes is that they offer independent external verification of the performance of institutions. While schemes like the ISO 14001 do not set any specific targets for organizations, they require that participating organizations identify clear environmental goals, conform to these goals as well as to subsisting environmental laws and regulations. In other words, the adoption of formal quality measures causes organisations to set targets and work towards achieving them. An online survey of HEIs energy policies shows that only a handful of institutions (11%) have included ISO 14001 certification as part of their environmental policy goals. Another example of such external and independent benchmarking schemes is the 'Business In The Community' (BITC). The report of a benchmarking project which sought to compare the environmental and corporate responsibility credentials of 25 universities with the performance of the wider corporate society was released in 2007 (BITC 2007). Even though this was a scoping study, it was an opportunity for the participating institutions to benchmark their performance against other sectors of the economy. Such third party designed and monitored assessments have great potentials for driving improvements in energy efficiency and environmental sustainability in subsectors.

## 5. Discussion

The relevance and effectiveness of public policies depend to a large extent on their capacity to identify evaluation frameworks and baseline indices by which effectiveness can be accurately

gauged. One of the key challenges facing the assessment of intervention programmes in the higher education sector is the lack of an assessment framework with suitable indicators with which the various impacts and associated causes and consequences of each programme can be evaluated and cross-compared. The case of HEIs' energy and carbon emissions reduction is made more complex by the heterogeneity of the sector. A key first step in any future assessment studies would be to identify the range of interventions and establish goals of the different aspects of each programme along with relevant indices.

The processes for identifying evaluation frameworks and baseline indices will essentially provide deeper insight into issues associated with energy consumption in the higher education sector. In energy efficiency programmes, this means defining the opportunities and barriers associated with the uptake of energy efficient technologies and behaviours in the form of needs assessment. Some of the issues that may be addressed sector wide needs assessment involving identification of opportunities for improvement of efficiency levels and reduction of absolute energy consumption. Some enquiries at this stage may centre on identifying the thematic, temporal and spatial scopes for future interventions and policies. Moreover, it is important at this stage to use relevant quantitative and qualitative parameters to identify and quantify the energy efficiency problems facing the sector. The Carbon Trust HECM programme adequately addresses this issue and helps HEIs establish baseline conditions and identify opportunities and barriers to carbon emissions reductions. The current participation level of universities in the 3-year life of the programme is quite high and commendable. It is possible to build on findings of these assessments in order to establish sector wide formal baseline scenarios for reductions in energy consumption.

Understanding the mechanisms of change of energy use in the higher education sector presents the key to strategic planning for energy demand and use and lays the foundation for effective interventions design. This makes it essential to identify the growth factors in HEIs and to associate these factors as closely as possible with end-use demand for energy. This separation is necessary because not all structural changes result in changes in the demand for energy. Such disaggregation therefore allows the individuation of the effects of different changes within the sector on energy consumption. It is also important to distinguish between the energy consumption drivers and mitigating factors and understand how these factors interact and change over time.

These compounding factors may be technological, behavioural or economic. For instance, it may be argued that the key driver for space heating is the treated floor area or space volume. Similarly student numbers may be seen as a key driver in energy demand in academic areas, while the intensity of demand for computing and the occupancy hours in the buildings are the mitigating factors. Such key element of problem fact finding will identify and characterise energy end-uses in the sector. One of the findings of the interventions survey carried out is the existence of a strong link between activities within buildings and energy demand, an indication that energy demand in the sector may be driven to a smaller degree by fabric loads. This suggests that there may be a lot of scope for reduction in energy consumption by adjusting activity patterns. It underscores the need to aggregate energy consumption into energy service demand factors and then determine the activities that are directly associated with the energy service. In this way the effects of compounding factors can be decoupled from the impacts of the particular intervention.

There is a need for single or combined prescriptive indices that address the issues identified in the problem-orientated fact finding and needs assessment stages. Indeed, any approach to the systematic assessment of the efficiency of interventions should include baseline performance indicators against which future performance may be gauged. Tanaka (2008) lists some indicators that may be applied in the assessment of energy efficiency performance. These include: absolute energy, energy intensity, diffusion of specific energy-saving technology and thermal efficiency (ibid). While it is possible to use the indicators in sector wide assessments, sever limitations exist in the use of thermal efficiency as an indicator. Some of these limitations are associated with the level of data required and the complexity associated with establishing actual thermal efficiency of buildings.

The use of absolute energy indicators allows for a simple year on comparison between the pre and post intervention years or against a baseline year. The main advantage of absolute energy indicators is their ability to highlight the overall impact of a sector's contribution to regional and national energy demands. The EU ETS, the Climate Change Agreements (CCA) and the proposed CRC are based on absolute emissions reductions. The overall absolute energy consumption and carbon emissions in the UK higher education sector increased by about 3% and 4.3% respectively

between 2001 and 2006 (Ward *et al*. 2008). In order to achieve appreciable progress towards carbon reductions, it is important that absolute targets are set for the higher education sector.

Several energy intensity indicators are used to provide evidence of energy performance of sectors. These indicators are often simple ratios linking energy consumption and variables that are representative of the sector's activities. One of the key issues arising from the higher education studies is that there is a need to identify appropriate parameters to gauge energy intensity. In industrial processes, the product or physical output is often linked to the energy expended in the process to derive an energy intensity value. The difficulty with the HEIs is that the outputs are not tangible and the boundary definitions for different institutions vary significantly. The review by Ward *et al.* (2008) revealed that the use of indices involving student numbers and floor areas yielded different degrees of correlation with energy consumption for different categories of HEIs across the UK. The study also noted that research student numbers rather than overall student population had a closer correlation with energy consumption. However, not all higher education institutions have research students and so an index based on research student numbers may not provide a robust measure for sector wide assessments. This situation highlights the issue of definition of boundary conditions for the derivation of indices. Similarly the heterogeneity of building types in higher education sector poses a big challenge in the definition of floor area based indices. Indicators are needed that will measure the environmental effectiveness of the policies and initiatives as well as gauge the distributional effects of the various programmes.

There are currently no statutory targets for carbon emissions reductions in the higher education sector. The modelling results of the 4CMR studies (4CMR 2006) indicated that the largest relative reductions in energy consumption were expected in the industrial sector largely due to the effects of the Climate Change Agreements (CCA). The operation of CCA involves the setting of targets with incentives and penalties for reducing or exceeding targets. Empirical results cited by Hopkinson and James (2007) confirmed that the EU ETS cap and trade scheme recorded significant success in reducing the aggregate emissions in 40 universities that participated in the programme by as much as 10% points. This convergence of modelling and empirical results underlies the strength of programmes that set specific targets with mechanisms for monitoring, incentivising and penalising performance. A review of the energy and environmental policy

documents of HEIs available online suggest that emissions reductions targets are set based on voluntary perspective rather than mandatory one and mainly initiated by the Carbon Trust HECM programme. Hence the establishment of sector wide targets for energy and carbon reductions has potentials for achieving substantial reductions in energy consumption.

Allied to the limited specificity of the policies and targets is a general absence of pressure in practice either from peers or funding bodies to achieve higher levels of reduction in energy consumption and carbon emissions. There may be a need for an enforcement arm within the funding bodies to set performance targets, independently monitor performance and facilitate improvements within the sector through series of incentives and penalties. Additionally, there is a need for sector specific policies within the framework of exiting policies that address the specific energy consumption issues in the higher education sector.

## 6. Conclusion

One of the findings of this review is the lack of any formal methodology for the assessment of the performance of energy efficiency interventions and policies in the UK in general and in the higher education sector in particular. This may be due in part to the non-clarity of issues arising from the complex interactions that drive energy demand and use. There are also difficulties in establishing boundary conditions for the assessment of energy efficiency performance interventions for a heterogeneous sector as the higher education. A summary of the barriers identified in the review are as follows:

- Lack of methodology for intervention studies;
- Non-clarity of issues arising from the complex nature of energy demand and use;
- Difficulty in establishing boundary conditions for the assessment of energy efficiency performance in heterogeneous sector;
- The question of indices and their usefulness as performance indicators;
- The role of compounding factors in obscuring actual performance;
- Data quality and reliability;
- Outcomes are often aggregated, thus masking trends in the efficiency and efficacy of certain programmes.

A critical outcome of this review is the acknowledgement that, although there are policies and programmes aimed at carbon abatement and which may indeed deliver lower energy intensities in the sector, the overall goal of reduction in energy demand is more difficult to achieve given the levels of growth in the sector and its overall impact over regional and national economy.

This review has confirmed that mitigation has been the focus of the programmes currently on stream in the higher education sector. The obvious future challenge for the higher education sector is in its ability to adapt to the changes that are likely to occur in the energy sector. For instance, how will HEIs cope with very high energy costs? How robust and resilient are energy systems especially for high technology research facilities in HEIs?

A very important task for the future is to develop systems for effectively measuring and evaluating the impact of carbon emissions reduction policies, regulations and schemes in the higher education sector. This will require the development of consistent and comparable performance indicators for assessing the programmes.

Some very positive initiatives have emerged from within the higher education sector aimed at addressing sector related environmental concerns. Notable among these are the various networking and feedback loops available to discuss and share experiences. These include Environmental Association of Universities and Colleges, Sharefair and the Association of University Directors of Estate. It is difficult to ascertain the extent to which these groupings have impacted positively on energy management in the sector, however it is believed that they are potential vehicles through which peer review and pressure may be brought to bear on institutions environmental performance.

Policy reforms adjusted to and targeted at specific sector conditions are more likely to result in positive changes. The higher education sector in the UK is growing in scope and importance in the economy and so is the sector's demand for energy. The drivers of growth appear to be increased student numbers, diversified course types, and increased intensity of research activities. These drivers of growth have in turn brought about changes in estate sizes, higher intensity in the use of facilities and greater energy intensive research equipment and activities. Unfortunately the policies currently in force in HEIs are of a generic nature and do not adequately address the energy demand factors in the sector.

There is a need to establish clear targets for carbon emissions reductions within the sector. Evidence suggests that success of emissions reduction schemes has often been associated with the setting of clear targets based on fully characterised baseline scenarios. The baseline energy and emissions scenarios for the higher education sector are presently unclear, which requires further investigation to create a reliable foundation for target setting. Without these baseline scenarios, it is also very difficult to assess the environmental effectiveness of the existing policies and initiatives.

A larger proportion of the carbon reduction schemes currently in place in the higher education sector are 'soft touch'. It is believed that formal reviews and monitoring of HEIs' energy and carbon emissions schemes involving the funding bodies and third parties will provide additional impetus towards the drive for lower energy consumption and reduction in carbon emissions.

Although there is a concern that financial incentives for green purchasing may offer benefits to the participating HEIs, there is really no guarantee that this will result in reductions in overall energy consumption. Ward *et al.* (2008) report a 2.7% increase in sector wide energy consumption levels in the past six years (2001-2006), in spite of the 9% increase in the share of renewable energy sources in the sector in the mean time. The general inference drawn form this is, though taxes and charges may offer financial incentives for adoption of renewable technologies, that they do not necessarily guarantee reductions in energy consumption.

There are opportunities at the sectoral level to change growth and development pathways towards lower emissions through a range of measures. The key to the implementation of such measures is to maximize the synergies arising from the combination of measures and to set stringent targets while minimizing any long term negative impacts on the social, economic and environmental development of the sector.

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