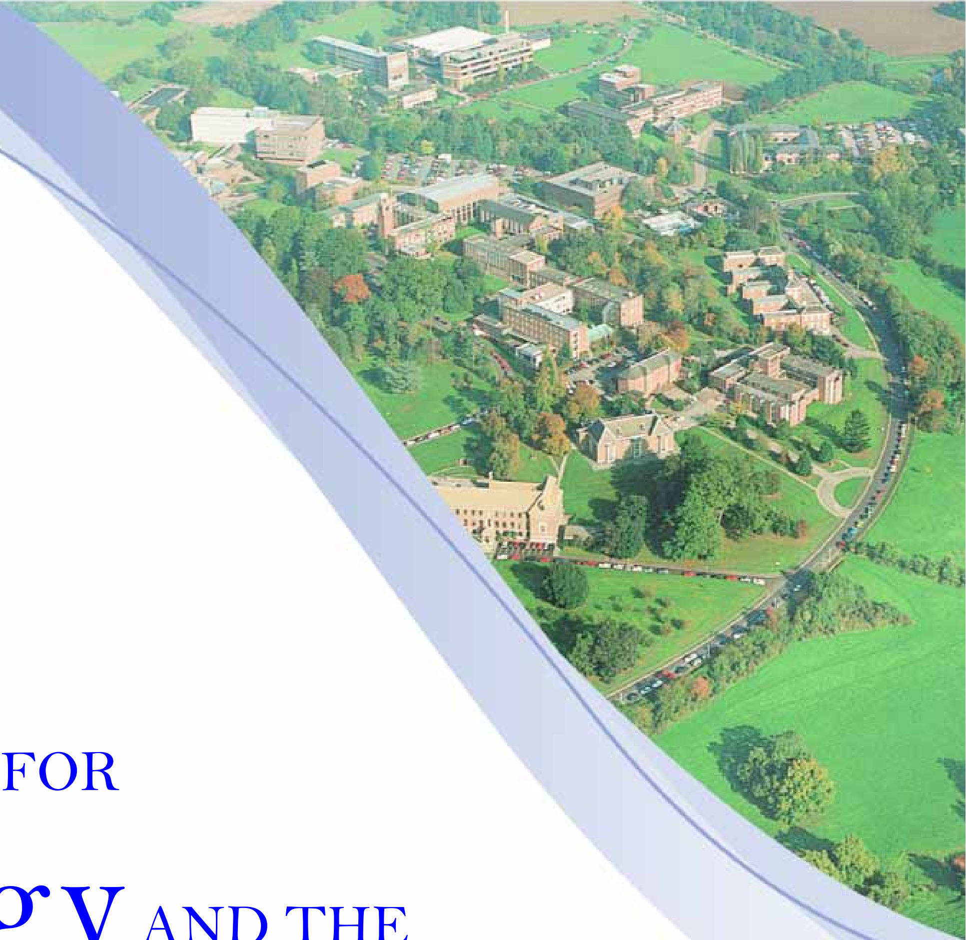

Centre for Energy and the Environment

Annual Report

2008

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Centre for Energy and the Environment

Annual Report

2008

A member of the South West Energy and Environment Group (SWEEG)

Full SWEEG Members
Devon County Council
Cornwall County Council
Torbay Council
University of Exeter

Associate SWEEG Members
Exeter City Council
Somerset County Council
Plymouth City Council
Devon and Cornwall Police Authority
REGEN SW

Organisations wishing to join SWEEG should contact the scientists at the Centre for Energy and the Environment in the first instance, who will be pleased to discuss the benefits and likely costs of membership.

Contents

Preface

This annual report marks the beginning of a new chapter for the Centre for Energy and the Environment, with the appointment of a full-time Head of Centre to take the reins and drive the Centre forward. Taking up this appointment is a really exciting prospect at a time when the challenges of climate change and energy security are really beginning to have an impact on our daily lives. Meeting these challenges will be difficult and will require innovative solutions. The opportunities for the Centre and SWEEG to play a part in developing these solutions and to provide leadership in the region are great.

With barely more than a month in post I am still very much learning the true extent of these opportunities and what we have to do to make the most of them within the Centre. The SWEEG partners will be central to our success with these opportunities, as a unique collaboration between a University and Local Authorities. Through working together the Centre provides Local Authorities access to leading edge expertise and the authorities give the Centre real exposure to real problems needing real solutions. The true strength of this partnership is working at a strategic level providing solutions and ideas that can be implemented across our partner authorities. I want to ensure that we capitalise on this joint working to really add value to all the SWEEG members.

The drivers for action by Local Authorities are now stronger than ever. This year has seen the introduction of local area agreements, with national indicators that relate to climate change. This has been the first time that Local Authorities have had a formal requirement to develop strategies and take action in the area of climate. This is complemented by the Carbon Reduction Commitment which will provide a financial benefit for reducing carbon emissions from the Local Authority estate. Both of these mechanisms are still developing and I hope to be working across the SWEEG members to ensure we learn from each other's experiences and are at the forefront of responding to these challenges.

Looking beyond the SWEEG partnership, the Centre and the University has expertise that has not been fully exploited. There are opportunities regionally, nationally and internationally where the Centre should be playing a greater role, both to share its expertise and to bring learning back to the region. I want to develop our reputation and that of the work we have done with SWEEG more broadly, to ensure that we make the most of these knowledge transfer opportunities.

This annual report sets out the highlights of the work of the Centre over the last year, showing the breadth of skills and experience we have. I hope it will be as inspiring to you as it has been to me in seeing what the Centre does. I look forward to the challenges that will come over the following year, and to being able to report on our successes in a year's time.

Dr Guy Hitchcock
Head of the Centre for Energy and the Environment
October 2008

A Message from Councillor Roger Giles, SWEEG Chairman

The UK's former Chief Scientist Sir David King said in 2003 that climate change was the greatest threat that we faced. He also said that climate change was a greater threat than terrorism. Prime Minister Tony Blair may not have appreciated the comparison; however the comments certainly raised the profile of climate change, and galvanized action to combat it.

Governments as well as Local Authorities have introduced climate change mitigation policies in the last few years. The government has tough CO_2 reduction targets, and is busily promoting sustainability and the production of renewable energy. But here in the South West, we have been ahead of the game for a long time. For thirty years SWEEG has been working on practical examples of sustainable construction, and a reduced environmental footprint.

As a Devon County Councillor I believe we are very fortunate to have the Centre for Energy and the Environment in Exeter. I look forward to the partnership between Cornwall and Devon and Plymouth and Torbay being even more successful in greening the South West, and helping provide a sustainable future through the work of SWEEG.

In the five years since Sir David King's remarks there has been much more evidence of climate change, and more worrying projections of the effects of climate change. We can expect higher temperatures, more storminess, greater winter rainfall, and rising sea levels, and more areas at risk of flooding. The very future of some countries, and the homes of many millions of people are under threat.

2008 has seen a dramatic increase in energy prices. High energy prices and energy security and supply are increasingly likely to be key issues in the future.

Society has to look hard at reducing demand and making lifestyle changes. Government and Local Authorities – which I believe have a duty to exercise green community leadership – must do more to reduce energy usage and move towards carbon neutrality. SWEEG has a key role in working with local authorities towards achieving this.

Cllr Roger Giles
Devon County Councillor
Chairman of SWEEG

Farewell from the retiring Head of Centre

My ten years as Director of the Centre have been a very enjoyable experience and the co-operation of the scientists, officers and politicians in developing the role of SWEEG to answer new challenges has been a great source of pleasure and satisfaction. I have occasionally tweaked the rudder but the many changes that have taken place and the challenges in the future mean that it is time for a real captain and so it is with immense pleasure that I hand over to Guy Hitchcock as full-time Head of the Centre - a role which will include the part-time role of the Director. He brings complementary scientific knowledge to the skill base of the Centre and considerable managerial experience as well as full-time leadership in an ever-changing and developing environmental landscape.

In 1977, Professor Gerald Fowler had the vision, foresight and energy to persuade the Local Authorities and the University to embark on a collaborative venture. As I am probably the last link with that era, I would like to summarise what they hoped to achieve.

At that time it was for the Local Authorities to collaborate and share their knowledge and for the University to help them through the knowledge transfer process to understand how buildings could be made energy efficient and sustainable.

Of course they didn't use that form of words—they are today's buzzwords—but significantly it describes the current aims of the government. The outcome has been incredibly successful and the scope of the brief has expanded to meet fresh demands. All of the partners and their agents, current and former, can be immensely proud and Gerald, my PhD supervisor of fifty years ago, would himself have been very proud of the outcome.

I wish SWEEG and the Centre every success in the future and I am confident that together they can make a major contribution to the challenges that the region faces.

Trevor Preist

1. About the Centre and SWEEG

The South West Energy and Environment Group (SWEEG) exists to provide technical advice to its member authorities in the fields of energy efficiency, thermal comfort, sustainable buildings, building acoustics, sustainable transport, air quality and other environmental issues. Much of the work is strategic in nature and is hence of interest to several of the funding authorities. The group's work is disseminated at SWEEG meetings and in reports, internal documents and briefing papers. Sometimes, work of wider interest is published in technical journals. Documents produced within the past year are listed at the rear of this report. A full list of publications is available on request, or is available in a searchable format on our website (http://www.ex.ac.uk/cee/publications/)

SWEEG partly funds a team of scientists located in the Centre for Energy and the Environment (CEE), which is part of the School of Physics at the University of Exeter. The team has a broad range of analytical skills, and these are complemented by expertise in computer-based mathematical modelling, electronic data logging and environmental measurement.

Areas of Expertise

The CEE is a leading source of strategic thinking and technical services on energy and the environment in the South West region. It has developed over the last 30 years, alongside SWEEG, supporting Local Authorities in meeting the challenges of the environmental impacts that we, as a society, exert on the world around us. The core of our expertise is in energy use and sustainability in buildings, particularly with regards the Local Authority estate such as schools. Over time we have researched and developed expertise in a range of other topics including building acoustics, air quality and sustainable transport. We will continue to develop our understanding in these related areas, as shown below, providing support to our SWEEG partners and others within the South West Region. Also, with the skills and expertise we have, we will be looking to contribute to the debate and research at the National and European level.

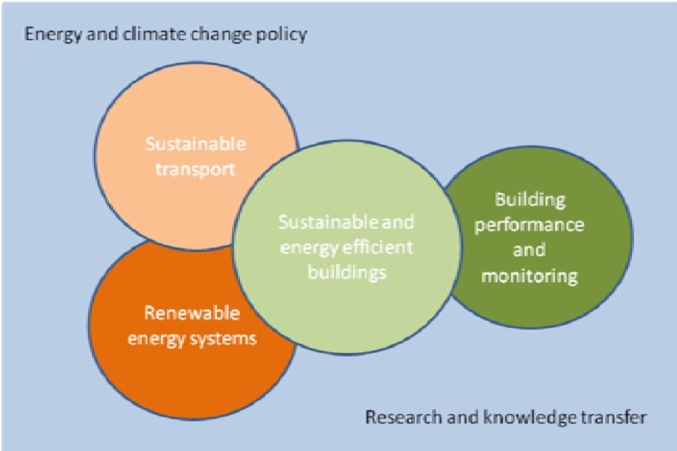


Figure 1. The CEE's areas of expertise.

The Centre now has a team of 8 staff funded through our work with SWEEG, commercial consultancy work and grants from Research Councils. The staff are from a wide variety of backgrounds and experience, providing an interdisciplinary team of experts. The Centre also has links with expertise across the University in areas such as mathematical modelling, engineering, geography and politics. As a University we also have a strong link with the Met Office and the work they are doing on the science of climate change. This annual report provides an insight into the range of work carried out by the CEE for our clients and partners over the last year.

Climate Change and Energy Policy

- Audits of regional energy use
- Audits of greenhouse gas emissions
- Support for carbon reduction strategies
- National carbon and energy policy drivers

Sustainable Buildings

- Advice on sustainable design
- BREEAM Assessments
- Building Energy Certification
- Daylighting simulations and calculations
- Energy auditing

Built Environment Performance and Monitoring

- Monitoring of building services performance
- Ventilation measurement and CFD prediction
- Acoustic design advice for buildings
- Measurement of the acoustic quality of buildings
- Environmental noise measurement and assessment

Sustainable Transport

- Localised emission modelling
- Regional air quality assessments
- Low carbon transport technologies and fuels
- Management of fleets and business travel
- Carbon reduction strategies

Renewable Energy Systems

- Renewable energy feasibility assessment
- Technology evaluation
- Low carbon developments

Research and Knowledge Transfer

- Climate change and adaptation
- Knowledge transfer partnerships (KTPs)
- Bespoke research

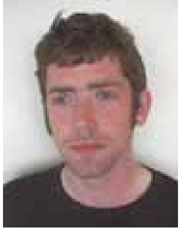
The CEE Team

Guy Hitchcock, *Head of the Centre*

Guy has some 20 years of experience in energy and environmental issues and has specific expertise in transport, climate change and air quality. He has carried out research and consultancy work for National Government, Local Authorities and private companies.

David Coley, *Senior Research Fellow*

David has experience in a wide range of fields including climate change, energy in buildings, thermal comfort, acoustics, renewable energy and electromagnetic fields. He has been involved in setting policy at a national level, and has disseminated his work in peer reviewed journals and books.



Dan Lash, *Research Fellow*

Dan has an architectural background and specialises in low energy building design, including daylighting, natural ventilation, thermal comfort and computer modelling. He is a CIBSE Low Carbon Energy assessor and a licensed BREEAM Schools assessor.

Andrew Mitchell, *Research Fellow*

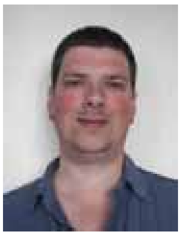
Andrew has over 10 years experience predicting and monitoring building and environmental performance, and specialises in acoustics, air quality, software production, and monitoring of buildings. He is a member of the Institute of Acoustics.

Ulf Winkler, *Associate Research Fellow*

Ulf joined us from the University of Plymouth in 2007 and has specialised in on-site measurement of energy use in buildings and advanced meter reading, biofuels and renewable energy.

Tony Norton, *Research Fellow*

Tony Norton has had a diverse career in the energy sector, and applies his experience across the South West in the field of low carbon development.



Tristan Kershaw, *Post Doctoral Research Fellow*

Tristan has recently submitted his PhD in Physics, and is working at the Centre on Prometheus—the EPSRC funded project on the impact of climate change on buildings.

Matthew Roberts, *Associate Research Fellow*

Matthew is the latest addition to the Centre having previously worked at the Environment Agency. He is engaged in the detailed monitoring of buildings, and the broader activities of the Centre.

2. Climate Change and Energy Policy

Introduction

Global carbon dioxide emissions remain high. This means that an increase in average global temperatures of two degrees centigrade is very likely. Since a rise of two degrees centigrade represents the threshold above which dangerous climate change could occur, reducing carbon dioxide emissions is vital. Last year, the Centre carried out a Devon-wide assessment of the potential for reducing carbon dioxide emissions. This was followed by work on action plans that contributed to the county's policy making process. This county-wide work placed the CEE in a strong position to contribute to Exeter's climate change strategy. Exeter City Council has since commissioned the CEE to undertake a detailed analysis of the City's options for reducing carbon dioxide emissions.

As well as reducing carbon dioxide emissions, it is essential that society prepares for the changing climate. Adapting the built environment to the weather conditions that will occur in future will form an important part of these preparations.

Figure 2. Initiatives to reduce carbon dioxide emissions are key to reducing the effects of climate change.

Devon Local Area Agreement

The CEE has played a significant role in establishing a robust evidence base for the setting of Devon Strategic Partnership's carbon emissions targets in the Local Area Agreement (LAA), which runs from 2008-2011. Initially, a review of estimates made by AEA Technology was carried out. This revealed that AEA Technology had severely over-estimated the reduction in emissions that would arise simply due to national policy being implemented. If these estimates had formed the basis of the LAA, the emissions reduction would have fallen short of the Government's target for 2020, which was stated in the draft Climate Change Bill. This shortfall is shown in Figure 3. Therefore, if Devon is to make a fair contribution to mitigating climate change, it is vital that this gap is bridged.

The CEE also carried out a detailed study of the effect of both national and local policy on carbon emissions, as measured using *Defra* National Indicator 186 (NI 186). NI 186 has been adopted as one of Devon's LAA targets (this indicator has also been adopted as an LAA target by almost every SWEEG member). It was discovered that national measures could distort any changes in the indicator, so the CEE performed calculations to account for both national and local policies. The results of these calculations were used to establish headline targets for the LAA, together with proxy targets so that the effectiveness of local policies could be assessed. In addition, the impact on NI 186 of the Devon Warm Zones project – a scheme that will help people in vulnerable households to improve the energy efficiency of their homes – was examined in greater detail, using a bottom-up approach. Finally, the impact of NI 186 on each of Devon's LAA targets was measured, where appropriate.

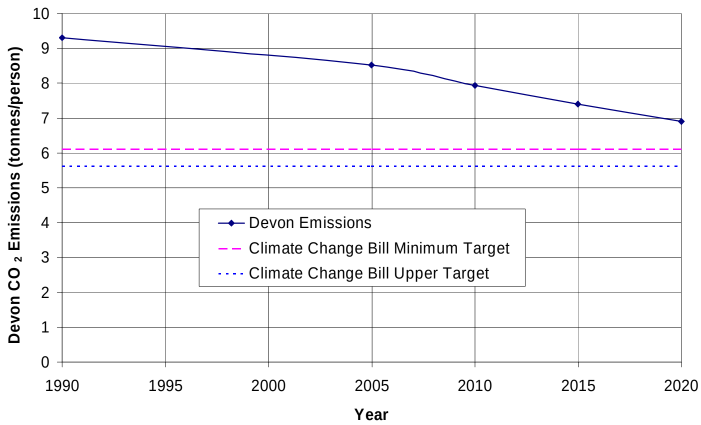


Figure 3. The CEE's analysis of the reduction in CO_2 emissions that will be achieved through national policy measures. The reduction falls short of targets set by the Government in the Climate Change Bill. This shortfall will need to be met by local initiatives.

The CEE will continue to work with Devon to monitor performance against both the LAA targets and the proxy targets, and to provide ongoing advice on regional carbon reduction and on any new mechanisms that emerge, such as Local Authority carbon trading schemes.

Sources of further information:

◊ *Internal Document 570:* Integrating national indicator 187 into Devon County Council's LAA targets together with the impact of Devon Warm Zones on national indicators 186 and 187.

◊ *Internal Document 571:* The Projected Impact of National Policy On Devon's CO_2 Emissions.

◊ *Internal Document 578:* Setting CO_2 Reduction Targets for Devon's Local Area Agreement using NI186 and Proxy Indicators.

◊ *Internal Document 581:* The Impact of Devon County Council's LAA Targets 2008-2011 on National Indicator 186.

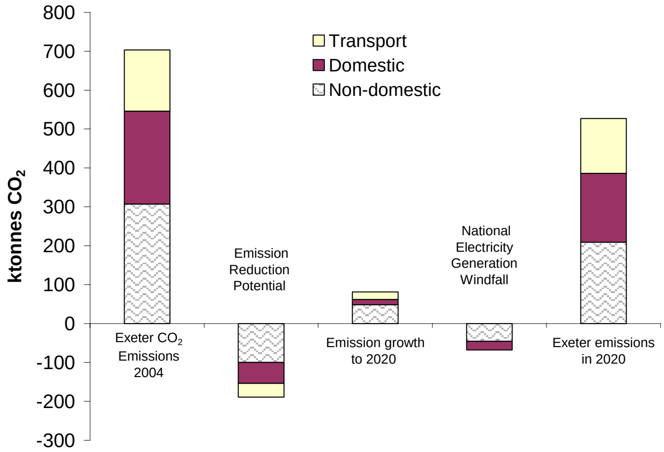


Figure 4. Data for Exeter: CO_2 emissions; potential for reducing emissions; projected increases in emissions due to employment and housing growth; reductions due to national changes in electricity generation between 2004 and 2020.

Exeter City Council Climate Change Strategy

The CEE was commissioned to assess whether the aspiration in Exeter's Draft Climate Change Strategy to reduce CO_2 emissions by 30% in 2020 (relative to a 1990 baseline) was feasible. The first stage in the analysis was to estimate baseline and recent consumption in three broad sectors: domestic, non-domestic and transport. This revealed that a 27% reduction from 2004 levels would be equivalent to a 30% reduction from 1990 levels.

A number of factors were considered when estimating the feasibility of such a reduction: national initiatives (as outlined in the 2007 Energy White Paper), local initiatives, and the effects of growth in population and employment. It was found that national initiatives alone would not be sufficient to achieve the target, and a number of locally targeted actions were identified:

- Achievement of best practice energy consumption in the non-domestic sector.
- Establishment of joint schemes to achieve cross-organisation energy optimisation in Exeter's industrial areas.
- Installation of energy reduction and efficiency measures in all of Exeter's housing stock.
- Eradication of areas with a high incidence of electrically heating dwellings by providing community heating schemes.
- Reduction of car use, including modal shifts to other forms, and the introduction of carbon reduction objectives alongside congestion as a driver for local transport policy.
- To limit the effects of growth in population and employment by implementing and enforcing low carbon planning policy.

These measures, together with national initiatives and the projected national change in emissions from electricity generation were found to offer a net emissions reduction potential of 25% of 2004 levels and 28% of 1990 levels, close to the 30% trajectory

Figure 5. A detailed study was conducted of strategies to reduce CO_2 emissions in the city of Exeter.

Sources of further information:

◊ *Scientist's Report 117:* Exeter Climate Change Strategy Analysis.

EPSRC Research: The ‘Prometheus’ Project

In ancient Greek mythology, Prometheus (Figure 6) is a Titan and is known for his wily intelligence. He stole fire from Zeus and gave it to mortals for them to use. Zeus then punished Prometheus for his crime. Prometheus is also an icy satellite of Saturn. It is perhaps fitting that ‘Prometheus’ is also the name of a research project associated with helping mankind to cope with the consequences of the Titan’s gift.

The project (which is funded by EPSRC, the Engineering and Physical Sciences Research Council) will attempt to create weather data (on an hourly time step) for future years and for various climate change scenarios, including an extreme scenario. These data will be used to predict how architecture would need to be adapted to ensure that buildings could still provide suitable environments for human occupation. Early results (Figure 7) show that a great variety of structures will be highly sensitive to a changing climate, and we might therefore need to consider form alongside material choice when designing buildings for the future.

Sources of further information:
http://www.ex.ac.uk/cee/prometheus/

Figure 6. Prometheus with the stolen fire.

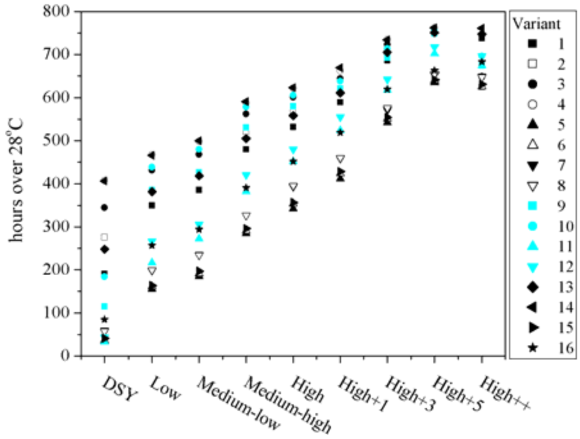


Figure 7. Initial results for a range of scenarios showing overheating hours for the present ‘hot’ summer condition (the DSY), and additional projected climate scenarios.

The Environmental Implications of Home Working

Home working is an attractive option for both the employer and the employee. The employer benefits from a reduction in the cost of providing and servicing floor space, and the employee avoids spending large periods of time commuting to and from the office. The CEE was asked to investigate whether there are also environmental benefits associated with home working.

It was found that the CO_2 emissions associated with heating a typical house during office hours were similar to the emissions caused by:

- a 10 km commute by car, if the house was heated by gas central heating, or
- a 27 km commute by car, if the house was electrically heated.

Furthermore, published figures suggest that the energy consumed in servicing an office is greater per occupant than that needed to heat a house (using gas) for the additional hours. Hence, home working is always beneficial to the environment if accompanied by a reduction in serviced office accommodation. When the house is heated electrically the comparison is not so favourable, but a commute of just 2 km will offset the increased energy used to service the house compared to the office.

Sources of further information:

◊ *Briefing Paper 94:* Some Environmental Implications of Home-working.

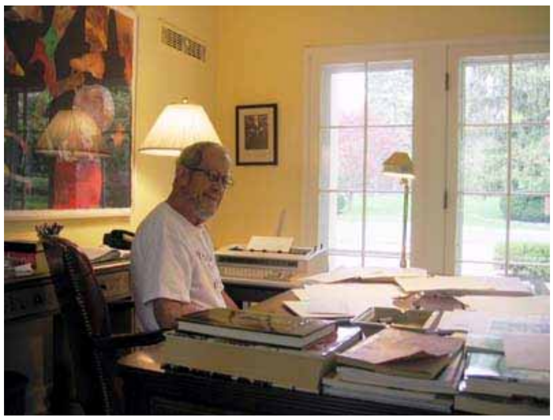


Figure 8. An example of home working.

Embodied Energy of Water

Torbay Council asked the CEE to establish figures for the embodied energy of water. The CEE was also asked to distinguish between the energy used in the supply of water and the energy used in water treatment. Finally, national figures were examined to see whether they could be applied to the South West. The comparison with national figures was important because pumping accounts for a large part of the energy used by a water company, and the amount of pumping required is affected by topography. The results are presented in Table 1.

It is interesting to compare the embodied energy of the water used by a typical school with its energy use. Rough calculations suggest that the embodied energy of the water will be around a tenth of that used in the form of electricity.

Sources of further information:

◊ *Internal Document 595:* The Embodied Energy of Cold Water Supply and Treatment.

Category	Energy used (kWh/m^3)	CO_2 emissions ($kgCO_2/m^3$)
National		
Supply	0.64 (0.35)	0.27 (0.14)
Treatment	1.35 (1.07)	0.57 (0.44)
Combined	1.99	0.84
South West		
Supply	0.71	0.30
Treatment	1.74	0.74
Combined	2.46	1.05

Table 1. Estimates for the embodied energy of water (with standard deviations).

Climate Change in Schools

At present, there is no requirement for building designers to take climate change into account. However, given the lifetime of most buildings and predictions for the future of the UK's climate, it would seem sensible to have some understanding of how a new building is likely to be affected by climate change. We often find that there is little margin between the predicted internal environment and the requirements of the building bulletins for schools. For this reason, we decided to run a test case on a single school, in the SWEEG region.

The most commonly used statement on the future of the UK's climate is contained in the outputs from UKCIP02 (UK Climate Impacts Programme 02). These can be used to create future weather years by morphing current weather data. The CEE can now do this for fourteen locations in the UK, for the years 2020, 2050 and 2080.

Figure 9 is an extract from a 'whole building' simulation, and shows the predicted air temperature in one classroom for a single summer week. We can see that the simulation using the weather file for 2080 results in a markedly different environment, which most would consider to be unacceptable.

Table 2 shows summary data for the whole summer period, for the two simulations. It can be seen that, under the weather conditions predicted for 2080, the building would be unable to satisfy the requirements of the building regulations (BB101). Therefore, we can conclude that there are grounds for concern. We also recommend that all future modelling of SWEEG schools incorporates weather files that represent the likely climate over the life-time of the building.

Sources of further information:

◊ *Internal Document 592:* The Impact of Climate Change in Schools: Some Initial Results.

Figure 9. Results for a single classroom during a summer week. The simulation for 2080 (solid line) predicts that temperatures could reach nearly 40°C. This is approximately 7.5°C warmer than the temperatures predicted by the simulation for the current design year (dashed line).

Scenario	Time for which temperature > 28°C (hours)	Maximum temperature (°C)
Current	91	31
2080	307	39
BB101 requirement	Less than 120	Less than 32

Table 2. Summary of results.

3. Sustainable Buildings

Introduction

Since emissions from the transport sector are increasing, there is an even greater imperative to reduce emissions from the built environment, both for new and existing buildings. This year, the CEE has continued to collaborate with SWEEG members on innovative and exemplar schemes, and to use existing frameworks, such as BREEAM, to promote low and zero carbon buildings in a strategic manner.

BREEAM at Strategic Level

Whilst the position of the CEE has always been that sustainability must be embedded within designs, the BREEAM methodology has continued to become better established within the industry. The CEE has played an active role in undertaking assessments in the SWEEG region and beyond, and in engaging with BREEAM at a more strategic level.

The BREEAM methodology has been updated in the last year. Potentially, the biggest change is mandatory post-construction testing. In theory, this should ensure that all measures adopted at the design stage are included in the completed building. Other changes include a general ‘raising of the bar’ to reflect improvements in ‘standard’ practice, and the introduction of the new *Outstanding* category.

The CEE has been working closely with Devon County Council and its Children and Young People’s Service (CYPS). The aim of this work has been to reconcile the Council’s strategic aims with the BREEAM credits available. As part of the consultation process, the CEE has been helping key stakeholders from both the Council and its framework contractors to understand the requirements of BREEAM, and to engage with the methodology in a structured way. The purpose of this consultation process is to ensure that the Council can fully meet its sustainability objectives (Figure 10).

In Cornwall, the CEE has been assisting the Council by providing a body of technical evidence for its Building Standards Review – a set of documents that describes the minimum standards that all framework contractors must satisfy. This ongoing piece of work will cover all areas of building design. One element of the work has involved adapting BREEAM to create a simple calculator checklist tool that can be applied to smaller capital building projects. Such a tool would typically be used in situations for which BREEAM would be too onerous a process (Figures 11 and 12). The danger in such projects is that sustainability is often not addressed in an objective manner. The checklist tool has been designed to help an architect to understand some of the issues that are relevant even to small projects, and contains embedded calculators to demonstrate compliance with various requirements, e.g. daylighting, and NOx emissions from the boiler. It is expected that the tool will be refined, and will then be tested on real Cornish projects.

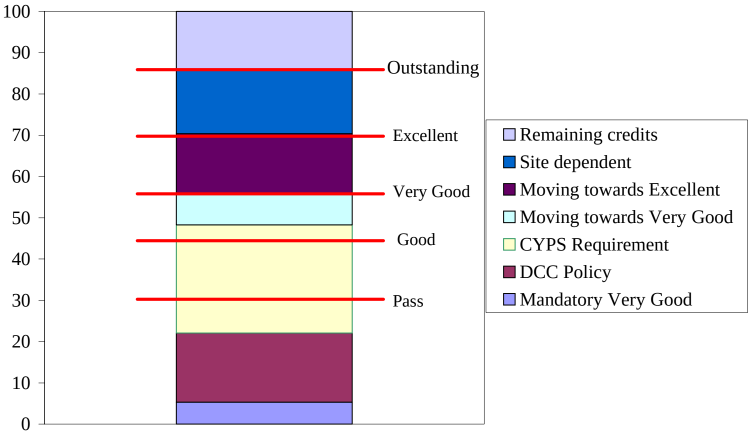


Figure 10. A breakdown of the BREEAM score to show the credits required to: satisfy DCC policy; meet the requirements of CYPS; and achieve a ’Very Good’ or ’Excellent’ score. Site dependent credits also shown.

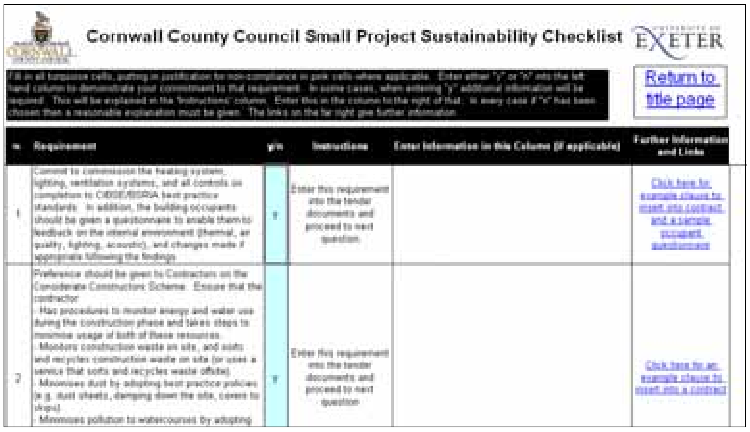


Figure 11. Sample extract from the draft spreadsheet tool to be used for small projects in Cornwall.

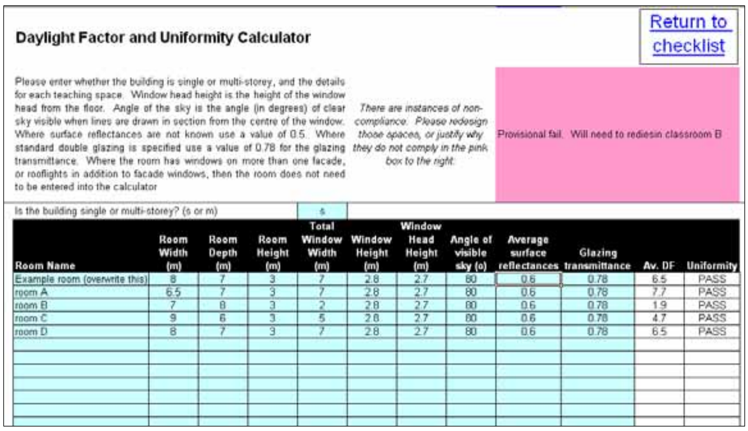


Figure 12. Calculator tools are embedded within the spreadsheet. These allow designers to efficiently compile the evidence needed to prove that the requirements have been met.

Overheating in new schools

Devon County Council commissioned the CEE to create a whole-building, thermal model of a new school. The simulated building needed to have a large number of classrooms with single-sided ventilation (Figure 13). The purpose of the exercise was to determine what fraction of the building would be unlikely to comply with the overheating and ventilation requirements of Building Bulleting 87.

The model showed that several rooms would be likely to overheat and a greater number would be likely to have insufficient ventilation (as measured by the fraction of the occupied period for which the rooms would fail to achieve an air exchange rate of at least 3 or 8 litres per second per person). These results confirm our position that, if at all possible, classrooms should have double-sided ventilation. If this can not be provided, the window openings need to be considered in great detail.

Sources of further information:

◊ *Internal Document 577:* Whole-building Thermal Modelling of St. Peter's School, Exeter.

Examples of Selected Building Projects

With the increasing use of framework contractors in the procurement process for Local Authority buildings, the CEE has, over the last year, demonstrated its flexibility by performing a wide range of roles in the design of such buildings. The CEE has been involved in design work for both new and existing buildings, and has promoted designs that reduce energy consumption and create a comfortable environment for occupants.

The CEE's ongoing involvement with Bideford College is a good example of consultancy work that reflects the historic working relationship between the CEE and members of SWEEG. The CEE was integrated into the design team for Bideford College as the first sketches were being considered over two years ago. In the last year, the design stage has been completed, and Part L compliance simulations have been performed on the final designs. The proposed solution – which makes use of cross-sided natural ventilation, natural lighting and a biomass boiler – will have very low emissions of carbon dioxide but will still provide a comfortable, well-lit internal environment.

The CEE has the ability to produce thermal comfort simulations, energy simulations, Part L submissions, daylighting simulations, acoustic calculations and BREEAM Schools consultancy reports. All of these abilities were used in a smaller project at the Park School, Barnstaple and, once again, the outcome was a building with effective natural lighting and ventilation Figures 14 and 15).

Whilst the Centre can provide traditional consultancy services directly to design teams, it can also play a vital role in representing the interests of the client.

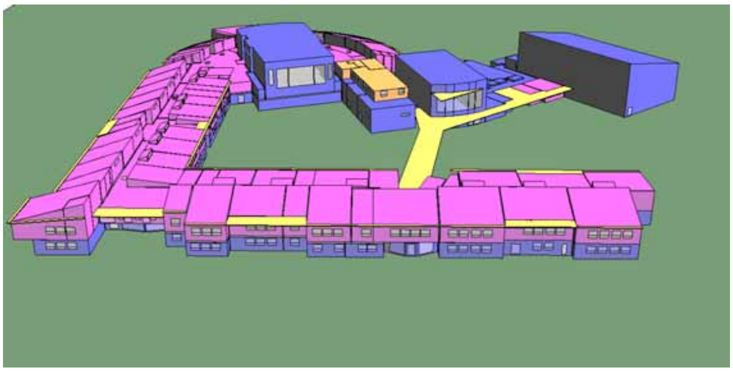


Figure 13. Visual impression of the school, as produced by the IES model.

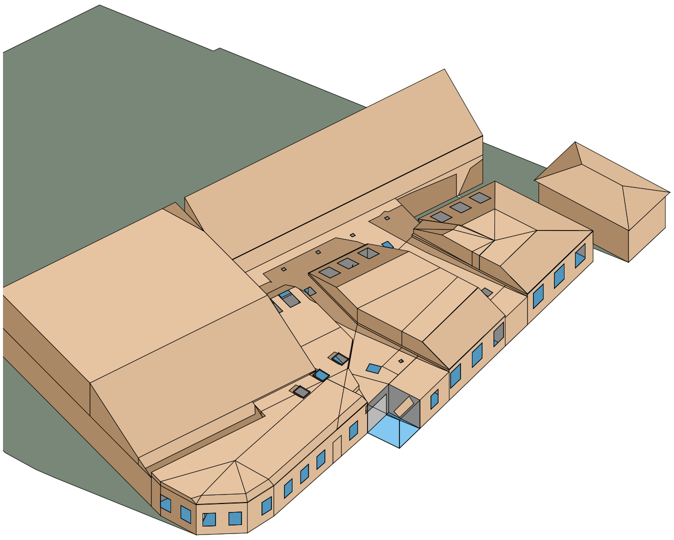


Figure 14. A view of the model constructed for the Park School, Barnstaple.

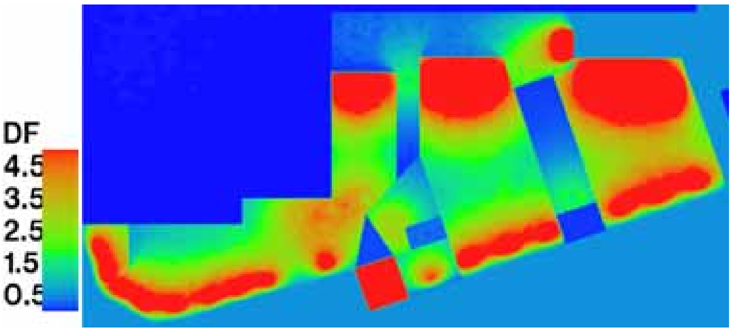


Figure 15. Daylight factors at the Park School, Barnstaple.

Such a service was successfully provided in the case of Estover College, which was commissioned by Plymouth City Council as part of the One School Pathfinder project (Figure 16). In this instance, the CEE was responsible for producing the sustainability elements of the specification, which then went out to bidding contractors. The Centre monitored the performance of the winning contractor against the objectives defined in the specification, and offered expert advice at regular intervals to ensure that the sustainability aims of the project were upheld.

Figure 16. An impression of the new campus at Estover Community College (image courtesy of Feilden, Clegg and Bradley Studios).

The expertise of the CEE has also been applied to existing buildings. At Roebuck House, Torquay, reports of overheating were investigated by examining BMS temperature data for each floor level. These data were used to calibrate a computer model. The calibrated model was then used to simulate the effect of retrofitting a solar control film. From this, an informed solution, to balance comfort, environmental and economic requirements, could be proposed.

Sources of further information:

◊ *Internal Document 588:* Assessing the Payback Period of Retrofitting Solar Control Film to Roebuck House, Torbay.

Energy Certification

Between the summer and autumn of 2008, legislation linked to the Energy Performance of Buildings Directive was introduced. As a result, an Energy Performance Certificate (EPC) will now be required for any building that is constructed, sold, or rented. Furthermore, a Display Energy Certificate (DEC) will be required for any public building with a floor area greater than 1000 m². These certificates will be similar in appearance to the well established labels on the packaging for light bulbs, and it is intended that they will educate and inform the users of buildings. The CEE has developed the capability to produce DECs, and is in the process of gaining accreditation needed to produce EPCs. Currently, the CEE is involved in producing a DEC for each building within the estate of the University of Exeter that is subject to the new legislation.

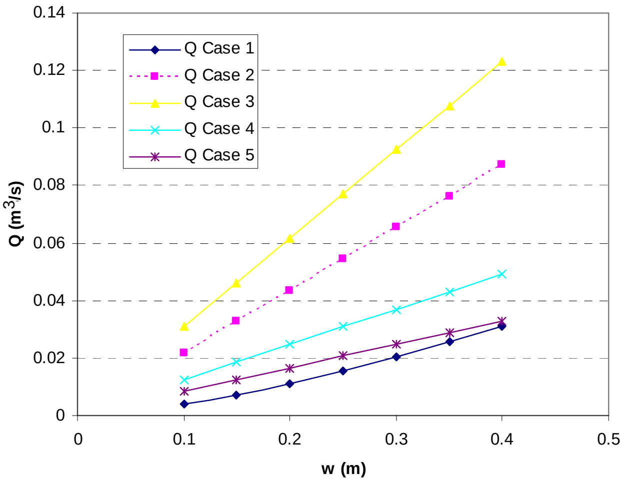


Figure 17. Ventilation flow rates for different types of window.

Windows: which type works best?

Devon County Council asked the CEE to investigate what effect different types of window opening would have on the ventilation rate a window might provide. An analysis was carried out using standard buoyancy equations. It was found that, at low to zero wind speeds, a window with a pair of top-hung panes could provide several times the ventilation of a window with a single top-hung pane, but only 70% of the flow of a window with a single, centre-pivoting pane (see Figure 17). This is an important finding, as pairs of smaller, top-hung panes would be less likely to protrude beyond the building line and could therefore present a smaller hazard on the ground floor. Figure 18 shows the types of windows studied.

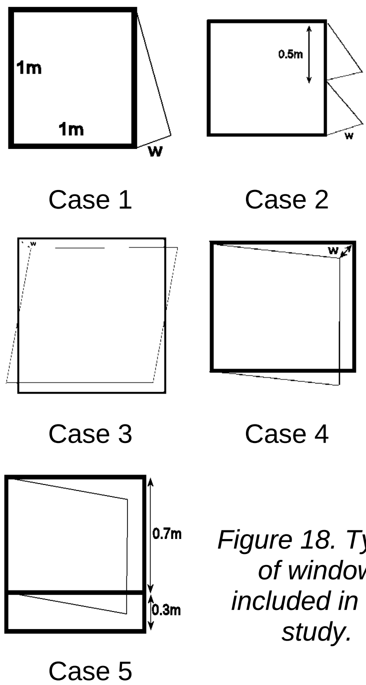


Figure 18. Types of window included in the study.

Additional modelling was carried out to examine the effect of making the lower part of a window non-opening. This is a common safety practice and reduces the possibility of objects (or people) accidentally falling out of the window. It was found that, in general, a 50% increase in opening distance would be needed to achieve the same flow rate.

Sources of further information:

◊ *Internal Document 589:* A Comparison of the Ventilation Provided by Different Window Opening Options.

4. Built Environment Performance and Monitoring

Introduction

The CEE continues to be active in the monitoring of building performance and other environmental parameters. This is important since only on-site monitoring can reveal shortcomings and dangers due to factors that may have been overlooked at the design stage, or due to poor standards of workmanship. Monitoring may also be necessary at the design stage to confirm or dispel concerns about exposure to noise, electric and magnetic fields and other phenomena.

During the past year, monitoring has been conducted to determine levels of electricity consumption in schools, overheating in schools (see Sustainable Buildings section), acoustic performance and environmental exposure to noise and magnetic fields.

Analysis of Electricity Consumption at a Torbay School

Regular, repeated monitoring of electricity consumption can reveal interesting patterns of energy use and can help to identify potential savings. The CEE was commissioned to examine one of Torbay's primary schools and to determine whether upgrading the lighting system and improved housekeeping could yield a significant reduction in electricity consumption.

Figure 19. Clip-on current loggers can be used to determine variations in electrical load.

Electricity consumption was monitored at half-hourly intervals using an optical meter reader, current clamps and data loggers (Figure 19). The readings revealed that the consumption per pupil was slightly poorer than the 25^{th} percentile for UK primary schools, and hence significantly better than average. Nevertheless, a number of possible energy saving measures were identified.

Firstly, baseline consumption was found to be relatively high at 3.5 to 4 kW. Some of this load may be deemed to be essential (e.g. refrigeration equipment and external security lighting). However, it was noted that the data projectors provided in each classroom did not have accessible isolation switches and hence were left on standby. This could account for up to 10% of the baseload consumption. A further 10% was attributed to baseline consumption in the IT suite (possibly servers and network peripherals). Secondly, it was found that lighting levels in several rooms far exceeded current requirements; a reduction to the statuary minimum could yield a reduction in lighting load of about 15%.

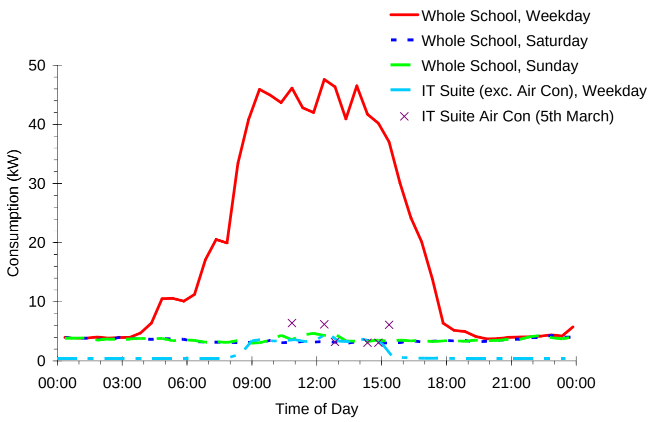


Figure 20: Average electricity consumption profiles for the Sherwell school.

Electrical consumption in the IT suite during lessons was found to be about 10% of the electrical load of the school. However, the peak load of the air conditioning in these spaces (which operated only briefly, since monitoring took place in the winter and spring) more than equalled the load of the computers.

Sources of further information:

◊ *Internal Document 584:* Electricity Saving Opportunities Identified by Half-Hourly Monitoring at Sherwell Valley Primary School, Torquay.

Acoustic Performance

The CEE continues to provide a substantial amount of acoustic design advice to Local Authority design teams. Progressively, more design work is being contracted out to private architects.

Cornwall County Council has been conducting a review of the standards that are being achieved in today's schools. The aim of this review is to improve the procurement process, so that higher standards of delivery can be achieved in the future. As part of this exercise, the CEE was asked to evaluate the acoustic performance of a number of recently constructed school buildings. Additionally, the large body of evidence amassed from other site tests was assimilated, and common causes of under-performance were identified. The body of evidence was also used to identify cases in which these problems had been addressed successfully.

The most common difficulties were identified as:

- Excessive noise levels from mechanical ventilation systems which did not incorporate sufficient sound attenuation. Noise from wall-mounted server cabinets was also a common problem.
- Some school halls, sports halls and drama studios are still being constructed without any sound-absorbent surfaces, resulting in spaces with excessive reverberation. Most classrooms were provided with acoustically absorbing, tile-in-grid ceilings. This offered sufficient control of reverberation.
- Walls were frequently found to under-perform in terms of sound insulation. This was mainly due to service penetrations, and to flanking transmission via lightweight metal roof systems, ventilation ducts, doors and corridors. Attention to detail is required if predicted levels of sound insulation are to be realised in practice.
- Many designs had connecting doors or folding partitions between rooms. These were found to offer insufficient sound insulation due to the poor alignment of seals and components.
- Floor constructions were found to perform quite consistently, enabling both airborne and impact noise requirements to be satisfied.

Sources of further information:

◊ *Scientists Report 119:* Achieving Acoustic Compliance in Cornish Schools.

Other Acoustics

Acoustic testing was carried out in Torbay, to determine whether the predicted levels of performance had been obtained in a new music and drama suite. These tests revealed that:

- The main mechanical ventilation system was sufficiently quiet.
- The provision of attenuators to reduce plant noise and cross-talk between rooms was successful.
- Reverberation had been controlled adequately.

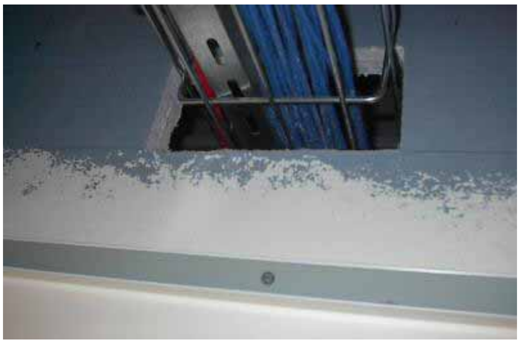


Figure 21. Unsealed service penetrations are easily concealed above tile-in-grid ceilings, and can compromise sound insulation performance.

Figure 22. Lightweight roofing systems can form a significant sound transmission path between rooms.

Figure 23. Server cabinets located in teaching spaces can lead to unacceptable levels of background noise.

Figure 24. Adequately sealed service penetrations at Torquay Girls' Grammar School Music Suite.

The least satisfactory aspect was again sound insulation.

Whilst the walls performed well in some cases, doors were found to compromise the otherwise high levels of sound insulation, due to flanking transmission via corridors. Significant sound leakage through the acoustically-rated doors was also detected.

Design predictions have been made for a number of projects. Speech intelligibility has been assessed in open plan designs at Ottery St. Mary and Camelford primary schools, and noise surveys have been completed for a number of projects. Involvement with the substantial Bideford BSF secondary school project has continued as the design has developed, and specific solutions have been devised to ensure acoustic integrity. At Exwick Heights primary school in Exeter, measurements were made to verify the validity of complaints associated with an outdoor nursery play area: wheeled toys were being used on timber decking, the noise from which was disturbing teaching activities in the classroom below.

Figure 25. Acoustic door seals are prone to damage, particularly when fitted to the meeting stile of double-leaf doors.

Figure 26. Acoustic door seals need to be properly adjusted if they are to be effective.

Sources of further information:

◊ *Internal Document 559:* Post-Construction Acoustic Testing in Torquay Girls Grammar School Music and Drama Block
◊ *Internal Document 565:* Speech Intelligibility in the Heart Space at Camelford Community Primary School: Revised Design.
◊ *Internal Document 583:* Noise Impact Assessment of Cranbrook Educational Campus.
◊ *Internal Document 574:* Noise Impact Assessment of Developments at Montgomery Primary School, Exeter.
◊ *Internal Document 576:* Noise Impact Assessment of Developments at Newton Poppleford Primary School.
◊ *Internal Document 495:* Building Bulletin 93 Compliance Assessment of Bideford College.
◊ *Internal Document 554:* Assessment of Impact Noise Transfer from Foundation Unit Outdoor Play Area to Key Stage 2 Classroom, Exwick Heights Primary School.

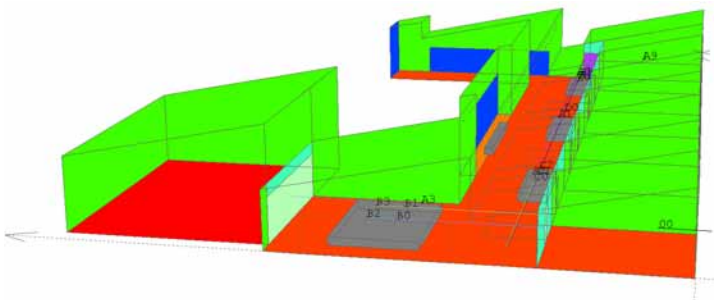


Figure 27. Geometric acoustic model of Camelford Primary School, used to predict noise disturbance in the open plan resource areas.

'Thin Client' Networks

Traditionally, the thermal performance of buildings has been strongly influenced by high levels of heat gain from occupants. Although this presents a challenge, since poorly designed school buildings will have a tendency to overheat, it also presents an opportunity: the metabolic heat gains can significantly reduce space heating energy requirements.

In recent years, the rapid growth in information technology provision in schools has led to further challenges due to even greater classroom heat gains. This frequently leads to overheating, discomfort and requests for the installation of energy-consuming air conditioning plant. The CEE has previously measured the energy consumption of a range of IT equipment. More recently, an investigation has been carried out into the energy consumed by 'thin client' networks. In these systems, most of the computer processing is carried out by the server. Since individual computer terminals can therefore be of a far lower specification, energy consumption and heat output can be reduced.

Figure 28: A cluster of 'thin client' PCs.

A brief literature survey suggested that a thin client server with a separate liquid crystal screen would use about 20% less energy than a laptop, and a thin client machine with a built-in display would cut energy consumption by one-third. These savings would be partially off-set by increased server-side energy consumption, but the servers could be located in spaces where heat gain is less problematic.

Further measurements of various IT devices have been made and collated into a condensed list of typical values for use when thermally modelling school buildings.

Sources of further information:

◊ *Briefing Paper 97:* An Update on Power Consumed by IT Devices.

Magnetic Fields

The CEE was commissioned by Devon County Council to investigate the magnetic fields around three possible sites for a new primary school at Instow, North Devon. All three possible sites are close to high-voltage overhead power lines. In the UK, the exposure of the human population to magnetic fields is regulated by the Health Protection Agency (HPA). The HPA sets exposure limits and if these are exceeded further investigation is required. For magnetic fields created by the electrical power supply (i.e. at 50 Hz), the HPA has adopted the limit set by the International Commission on non-Ionizing Radiation Protection (ICNIRP), which is 100,000 nT (nano-Tesla). At present, there is no strong scientific evidence to suggest that field-strengths below this limit can adversely affect human health. However, several studies have suggested that biological mechanisms may be sensitive to weaker fields. Furthermore, some epidemiological investigations have shown a relationship between leukaemia rates and either proximity to power lines or the magnetic field strength to which people are exposed. This work has been used to propose that a precautionary limit of 400 nT be adopted.

The power lines near to the proposed sites for the school are shown in Figure 29. There are four power lines (two 132 kV lines and two 33 kV lines). Measurements were made at the three possible sites for the school (site A is shown in Figure 29) and also along a transect of the site (Figure 30). This transect clearly shows how the field strength decreases with distance from the power lines. The results shown in Figure 30 indicate that, even if the school were built at site A, the field strength would be much less than 400 nT, and would be similar to the field strength at the current school.

To help staff, pupils and parents to understand the size and relevance of the fields in question, comparative measurements were made in a typical house in Exeter. The results (also shown in Table 3) demonstrate that common electrical items can produce strong fields. It can also be seen that the field strength in many parts of the home (or school) is likely to be greater than that produced by the power lines at any of the proposed sites for the school.

Sources of further information:

◊ *Internal Document 594:* ELF Magnetic Field Survey for Instow School.

Figure 29. Aerial photograph to show the locations and voltages (kV) of the power lines. Source: Google Earth.

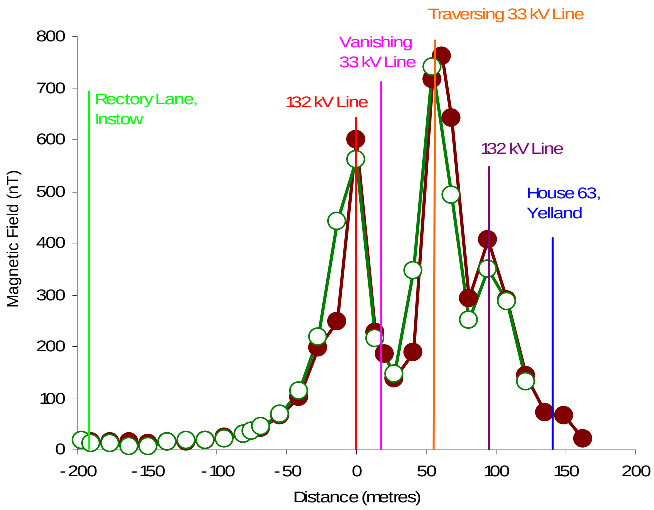


Figure 30. Chart to show measurements of magnetic field strength at different points along the transect line.

Location	Magnetic Field Strength (nT)
Site A (95 m from nearest 132 kV line)	24
Site B	4
Site D	13-32
Existing school grounds	8-19
Inside existing school	5-15
In the home	
In sitting room	1.8-4.0
Next to freezer	Up to 28
In upstairs bedroom	1.2-4.0
Next to shaver socket	>2000
Above bed (1m from clock radio)	Up to 55
10 cm from clock radio	1200

Table 3. Summary of measurements.

5. Sustainable Transport

Introduction

Transport accounts for about one-third of all our carbon emissions and is one of the few sectors for which emissions are continuing to rise. It was noted in the Stern Report that measures to reduce carbon emissions from the transport sector have the highest associated technical and social costs. As such, most forecasts show that emissions from transport will continue to rise well into the future, and that most mitigation strategies will only slow this rise, rather than achieve reductions. In addition, the dependence on fossil fuels and combustion engines makes the transport sector one of the major contributors to air quality problems in urban areas.

These two issues make transport an important but difficult problem to solve. The work of the CEE's staff has encompassed both of these areas by addressing carbon emissions from a particular authority's own activities and addressing local air quality problems and the carbon emissions relating to the authority's transport policies.

Figure 31: Increasing bus patronage has been considered as part of an analysis of Cornwall's carbon emissions from transport.

Analysis of the carbon emissions from Cornwall's transport sector

The Cornwall Local Transport Plan (LTP2) for 2006-2011 sets a variety of targets. These include:

- Reducing the growth in the number of vehicle kilometres
- Reducing the number of car journeys
- Increasing the number of journeys undertaken on foot, by bicycle or by public transport

The CEE estimated the amount by which carbon dioxide emissions would be reduced if these targets were achieved. Cornwall is a rural county, and the car is the dominant means of transport. At present, nearly 70% of all Cornish commuters drive to work in privately-owned cars, only about 3% use the bus and less than 1% use the train. A 4% increase in the number of bus journeys (by 2010/11, relative to 2003/04) and a 16.5% increase in the number of rail journeys (by 2010/11, relative to 2004/05), as forecast in the Local Transport Plan, would only have a small effect on the carbon emissions associated with the transport sector.

If all targets in the Local Transport Plan are achieved, it is estimated that annual carbon emissions from Cornwall's transport sector will be 0.5 ktC lower by 2010 than if the relative share of car, public transport, walking and cycling journeys remain at their present levels. For comparison, Cornwall's road transport sector emitted 380 ktC of carbon dioxide in 2005. It is predicted that this figure will have risen to at least 420 ktC by 2010, if measures to improve vehicle efficiency, or to replace fossil fuels with alternative fuels, have not been implemented.

Figure 32: A refuelling station for natural gas/ biogas buses in Bern, Switzerland.

National measures listed in the Energy White Paper 2007 offer much more potential for reducing the transport sector's carbon emissions. The White Paper predicts that, by 2009, each new car sold in the UK will emit an average of 140 g CO_2/kilometre (a value achieved by about 20% of all new cars sold in 2005). If this prediction is realised, emissions from Cornwall's transport sector could be 23 ktC lower by 2010 compared to a scenario in which the average new car efficiency remains at 2005 level of 170 gCO_2/km. A further reduction of 8 ktC may arise from minor measures listed in the White Paper.

A CEE study shows that the White Paper significantly over-estimates the transport carbon emission reduction potential of biofuels. It also advises against the purchase of flexi-fuel cars, which can be run on either pure biofuels or higher-concentration blends. The financial incentives that accompany the Renewable Transport Fuel Obligation (RTFO) are designed to promote the blending of biofuels with standard fuel, up to the permitted limit of 5%, but provide no financial advantage for users of flexi-fuel cars.

The CEE study also assessed the merits of using of LPG (autogas) or methane (either as fossil natural gas or as biogas) as vehicle fuel. Gas-powered vehicles generate lower carbon dioxide and pollutant emissions per kilometre than petrol or diesel vehicles. Worldwide methane resources are still far from being exhausted. In their pure forms, LPG and methane can only be used in spark-ignition (i.e. petrol) engines. However, compression-ignition (i.e. diesel) engines can operate efficiently on a mixture of methane and diesel. The conversion of a fleet of freight vehicles to methane-diesel dual fuel vehicles can pay back relatively quickly and could be the key to establishing methane as a vehicle fuel. In Cornwall, LPG (but not methane) has already gained a small market share as a fuel for cars. LPG is a by-product of crude oil and natural gas extraction. All by-products (methane, LPG etc.) from UK oil and gas fields must be used as heating or transport fuel, or as chemical feedstock, etc. Disposal of by-products by flaring is prohibited, other than in emergency situations. In most oil- and gas-producing countries, flaring of by-products is still common.

Figure 33: Depot for natural gas/biogas buses in Bern, Switzerland.

Sources of further information:

◊ *Internal Document 600:* Carbon Emission Reductions in the Cornish Road Transport Sector.
◊ *Briefing Paper 95:* Transport Carbon Emissions by Biofuels: Critical Assessment of Energy White Paper Projections.
◊ *Briefing Paper 96:* Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) as Vehicle Fuel.
◊ *Internal Document 555*: Biogas as Transport Fuel - Notes from the Biogasmax Friends Meeting on 30/01/2008

Understanding carbon emissions from an authority's own transport activities

The direct transport activities of a local authority can be split into three broad categories:

- Fleet vehicles - either owned directly or operated by a third party, including refuse collection vehicles and highways vehicles;
- Business travel - staff travelling for work purposes, on mileage allowances, in pool cars, in lease cars or via public transport;
- Commuting - staff travelling to and from work.

The key to understanding each of these is having good data collection procedures in place, so that information on fuel use, mileage and vehicle technology can be obtained. With fleet vehicles, direct fuel consumption figures should be collected where possible, as this gives the most accurate estimate of carbon emissions. With business and commuter travel, it is more likely that you will need to collect information on mileages covered and vehicle types.

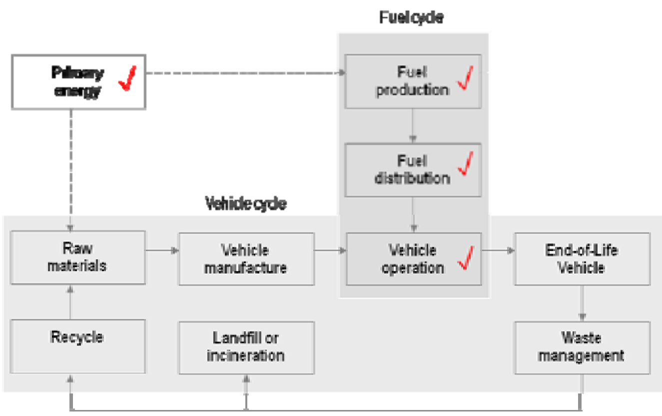


Figure 34. Transport fuel and vehicle life-cycles.

This information, with the exception of commuting, is what is required to assess transport emissions against the national indicator 185 (local authority estate carbon emissions). However, the collection of these data and ongoing monitoring is also essential to the management and reduction of emissions. Simple monitoring and target setting can cut emissions by 6% and measures such as driver training can cut these emissions further. Good monitoring also allows you to test and monitor reduction strategies, such as new fuel saving devices or travel plan measures.

A tool was developed to collate all these data and to calculate carbon emissions, to allow a baseline to be set and future monitoring to be carried out in a consistent way. The tool includes commuter travel and also calculates the indirect emissions associated with fuel production. These indirect emissions can increase the overall carbon emissions associated with transport activities by some 20%. This approach also allows the benefits of measures to reduce emissions, such as introducing biofuels or electric vehicles, to be compared in a comprehensive way.

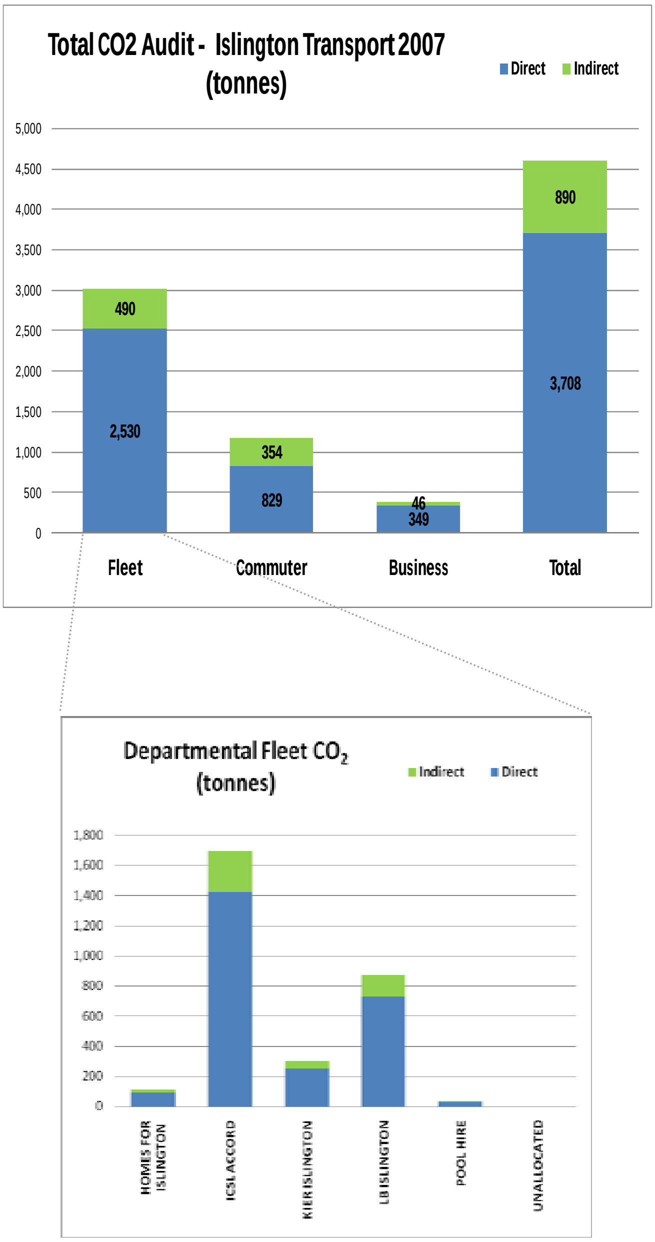


Figure 35. An example of the results from a CO_2 auditing tool.

Life-cycle emissions from biofuels

There has been much debate in the press about the environmental impacts of biofuels, but one aspect that has been largely ignored is the impact on air quality. A piece of work has been carried out to examine both the carbon emissions and the air quality impacts associated with the three main biofuels (biodiesel, bioethanol and biomethane), on a life-cycle basis.

If there are no direct or indirect land-use changes, most biofuels will have lower carbon emissions than fossil-derived petrol or diesel. However, there is much ongoing discussion about the emissions associated with land-use changes, and these emissions can have a big impact. Overall, biodiesel from used cooking oil, along with biomethane from sewage and waste, give the greatest carbon savings, of up to 85%.

The air quality impacts of these fuels are much more varied and difficult to unravel. Also, the data is much less robust. In general, it appears that tailpipe emissions of biofuels, especially in low blends, are barely different from those of pure fossil fuels. In several cases, however, the indirect or 'up stream' emissions make a much greater contribution to the overall analysis than tail pipe emissions. Clearly, though, these indirect emissions will not increase the impact at the point of use. The main causes of these indirect emissions are the agricultural processes involved in using rape seed and wheat as feedstock materials. These indirect emissions can lead to a total air quality rating that is worse than that for diesel or petrol.

Trying to assess both of these aspects is difficult, but it can be achieved using the Cleaner Drive methodology, which combines both the carbon and air quality impacts to give an overall impact. This analysis has indicated that most biofuels provide some environmental benefit compared to petrol or diesel. However, the benefits are relatively small for mainstream fuels, such as biodiesel from rape seed (RME) and bioethanol from wheat. The clear winners are biodiesel, from used cooking oil and biomethane, from waste, sewage or landfill. The environmental credentials of these waste-derived fuels are enhanced by the fact that there is no requirement for the land-use changes associated with crop-based fuels (such as biodiesel and bioethanol), and no increase in indirect emissions.

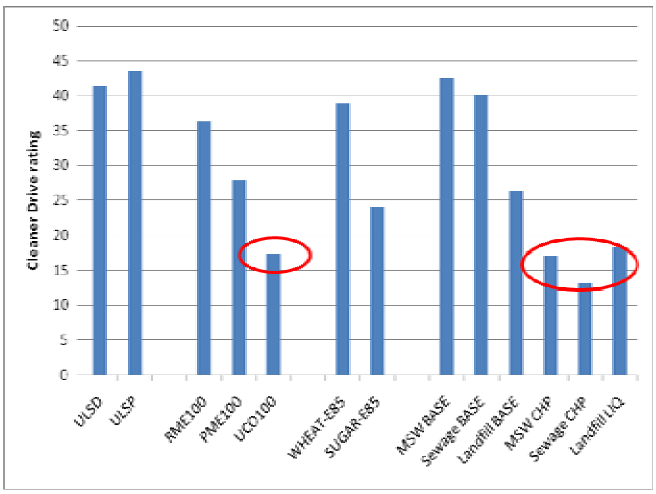


Figure 36. Combined Cleaner Drive rating for selected biofuels and petrol and diesel.

6. Renewable Energy Systems

Introduction

Measures to combat climate change can be separated into two categories: adaptation strategies, in which preparations are made for the impacts of climate change and mitigation strategies, in which attempts are made to minimise climate change by reducing emissions of greenhouse gases. Renewable energy is one example of a mitigation measure. Over the last year, we have examined the relevance of different technologies to various economic sectors in Devon, helped to formulate energy strategies for developments in Exeter and Plymouth, carried out a study into the positioning of wind turbines in school grounds, and produced software to predict the wind-shading effects of buildings.

RE4D Sector Analysis

As part of the RE4D project, the CEE has examined the possibility of matching on-site, low and zero carbon energy technologies to various sectors in Devon. Using existing data sources, a desk-based study was carried out to establish the energy demand and typical characteristics of each sector. Appropriate technologies were then assigned to each sector, in accordance with the predicted growth and uptake of each technology. The resulting body of work contains matrices and running commentaries on the relevance of each technology to particular sectors. It also contains useful headline energy information on each identified sector, drawn together from various sources.

Plymstock Quarry

With low carbon new development becoming a requirement and PPS1 giving local authorities a broad role in promoting the use of decentralised energy, the CEE has helped local authority planners to formulate energy strategies for developments in Exeter and Plymouth.

Wind turbines in school grounds

The CEE has recently produced software (called WSAT) to allow Local Authorities to study the effect of sheltering by buildings and trees on the capacity of wind turbines to produce energy. WSAT allows the user to enter the proposed location of the wind turbine, its height and power production curve, and the location and heights of nearby buildings. Using this information, WSAT estimates the fractional reduction in wind speed for all angles around the turbine site.

The new software was tested by studying the effect of sheltering on a typical turbine. Further simulations were then carried out to determine whether any general lessons could be learned about locating turbines within school grounds. Figure 37 shows one example of the type of data that WSAT can produce. In this simulation, estimates were made for the fractional reduction in wind speed (at hub height) at four different distances from the building. It can be seen that:

- The building's wind shadow is greater in magnitude the closer the turbine is sited to the building.
- The building's wind shadow also increases in angular width the closer the turbine is sited to the building.

With respect to locating a wind turbine in the grounds of a school, we can say that:

- The turbine needs to be taller than any buildings that lie between it and the wind.
- Even a building only half as high as the turbine hub can have a substantial effect.
- Even single storey buildings at least 100m away from the turbine may have an significant effect.
- Approximately, the sheltering effect increases rapidly (as h^2) with building height, h. Therefore, the positioning of the turbine relative to tall buildings, such as assembly and sports halls, is likely to be more important than the distance between the turbine and any single storey buildings (sheltering reduces approximately linearly with distance from the building).
- A deep building will create a greater sheltering effect than a shallow building.
- A building with a ridged or curved roof will create a smaller sheltering effect than a flat-roofed building of the same height.
- Given the importance of the sheltering effect, it would be advisable to consider the location of the turbine at an early stage in the design process, and certainly before the site plan has been finalised.
- A taller mast or a larger turbine will be needed if the sheltering effect is great. This will increase the overall cost of the scheme.
- A long run of buildings will have a much greater sheltering effect than a small, individual building of the same height. In general, the length of the run of buildings is related logarithmically to the overall sheltering effect.

Sources of further information:

◊ *Internal Document 550:* Siting Wind Turbines in School Grounds: thoughts on the sheltering effects of buildings.

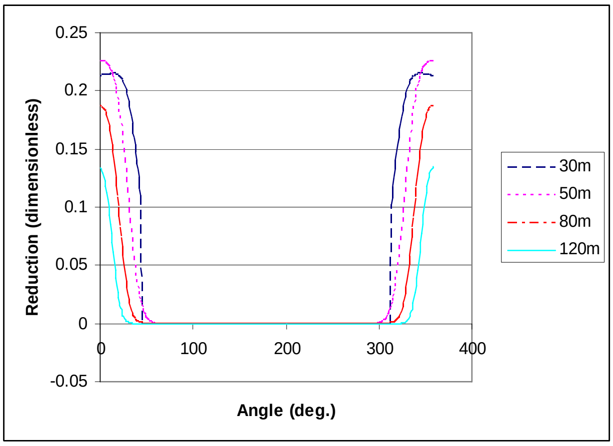


Figure 37. Fractional reduction in wind speed compared to the distance between a building of finite length and the wind turbine (the "angle" refers to the direction of the wind).

7. Research and Knowledge Transfer

Introduction

Both the CEE and SWEEG seek to transfer knowledge and promote good practice. Each year, staff from the CEE teach a module to Physics undergraduates. The CEE has also worked closely with Riverford Organic Vegetables.

International Food Miles

Over the last two years, the CEE has been helping Riverford Organic Vegetables to reduce its energy consumption and to carry out a carbon accounting exercise. As part of the latter, an investigation has been carried out into whether the concept of *food miles* is a useful indicator of the sustainability of imported food.

We have found very little correlation between the number of food miles and our estimates for the carbon emissions associated with transporting food from the farm gate to Riverford's packing house in the UK. Indeed, the carbon emissions associated with imports from parts of the Americas are lower than those associated with imports from the Eastern Mediterranean (Figure 38). We have therefore concluded that the use of food miles, as a measure of the sustainability of imported food, is unjustified.

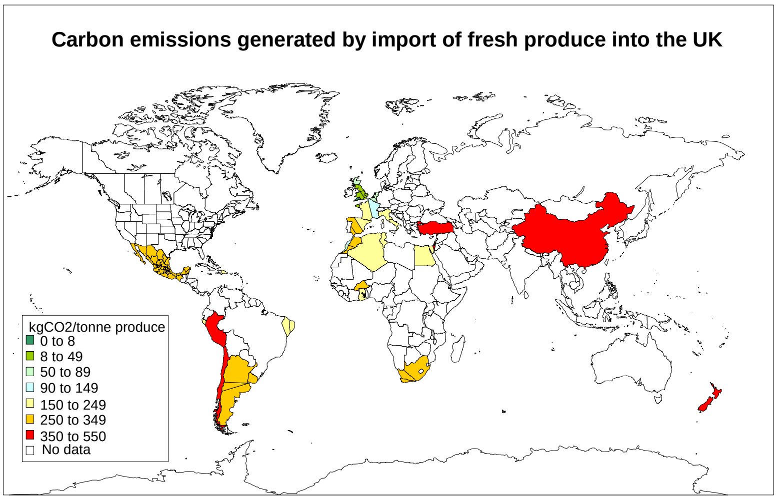


Figure 38. Representation of the CO_2 emissions associated with the import of fresh produce into the UK. Some countries of origin have been grouped into regions.

Energy and Environment Course

The Centre successfully delivered its popular *Energy and Environment* module to final-year Physics undergraduates again this year. The course provides an overview of conventional and renewable energy sources, and discusses issues surrounding energy consumption in the built environment and transport sectors. There is an emphasis on real-world skills including numerical analysis and estimation and report writing. The Centre also deliver part of a module on the renewable energy course at the Cornwall Campus of the University.

8. Publications

SWEEG publishes Reports, Briefing Papers, Software Documents and Internal Documents.

- Reports are based on in-depth studies that are often of general interest.
- Briefing Papers are usually responses to topical issues, or digests of technical or otherwise inaccessible information of interest to the membership.
- Software documents are instruction manuals for software written by the scientists.
- Internal Documents usually arise from investigations into a particular problem identified by a member, but they will often be of interest to others as case studies. Occasionally, there may be some restriction on the release of Internal Documents.

In addition, the CEE publishes material in technical journals and communicates the results of contract research to funding bodies.

A searchable list of documents may be found on the CEE's website (http://www.ex.ac.uk/cee/publications/), from which SWEEG members are able to download these documents. Publications issued during the past year are listed below, and a full list of publications is available on request. Other bodies may request the supply of documents on request.

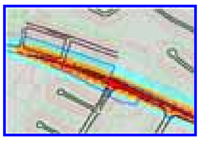
List of Publications for 2008

Number	Title	Author(s)	Pages
	Scientist's Reports		
117	Exeter Climate Change Strategy Analysis	S.F.S. Hunt, T.A. Mitchell, A.D.S. Norton & U. Winkler	74
118	Heat Loss through Ground Floor Slabs in Houses: a Comparison of Methods	F.Stift and D.A.Coley	25
119	Achieving Acoustic Compliance in Cornish Schools	T.A.Mitchell	28
120	Food Miles: a failed concept?	D.A.Coley and M.Howard	8
	Briefing Papers		
90	Wall absorption and scattering in large spaces	T.A.Mitchell	5
94	Some Environmental Implications of Home-Working	T.A.Mitchell	6
95	Transport Carbon Emissions by Biofuels: Critical Assessment of Energy White Paper Projections	U. Winkler	14
96	Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) as Vehicle Fuel	U. Winkler	17
97	An Update on Power Consumed by IT Devices	T.A.Mitchell	5
	Software Documents		
36	Wind Shelter Analysis Tool for Local Authorities (WSAT)	C.Ostridge and D.A.Coley	6
	Internal Documents		
465	Acoustic Compliance Assessment of an Extension to Churston Ferrers Grammar School	T.A. Mitchell	8
495	Building Bulletin 93 Compliance Assessment of Bideford College	T.A.Mitchell	47
532	Vibrations in Shaldon Bridge Parapet	D.A.Coley	7
533	The Relative Strengths of Electromagnetic Fields	D.A.Coley	1
534	Overheating in the New Exeter Schools: review of modelling	D.A.Coley	7
535	Acoustic Assessment of a Two Classroom Extension to St. Davids Primary School, Exeter	T.A.Mitchell	6
536	A Feasibility Assessment of Renewable and Low Carbon Energy Sources for the Primary School at the Camelford All Through Learning Centre	S.F.S. Hunt	18
537	Stage C Report on Acoustics, BREEAM and Zero Carbon Targets for the Camelford ATLC Primary School	S.F.S. Hunt	7
538	Modelling Top Hung Windows in IES	D.A.Coley	5
539	Carbon Offsetting	D.A.Coley and U. Winkler	10
540	Choosing Credits to Target in BREEAM Schools 2006	S.F.S. Hunt	6
541	Whole Life Cost Implications of Improving BREEAM Ratings	S.F.S. Hunt	3
542	Comments on National Indicator 186: Per capita reduction in CO2 emissions in the LA area	T.A. Mitchell	2
543	A Feasibility Assessment of Renewable and Low Carbon Energy Sources for Poltair Community School and Sports College's New Building	U. Winkler	22
544	Advanced Meter Reading for Torbay Council Buildings	U. Winkler	19
545	BB93 Compliance Assessment of an Extension to Torquay Girl's Grammar School	U. Winkler, D.A. Coley and T.A. Mitchell	21
546	Monitoring of energy consumption and internal temperatures in properties with Ground Source Heat Pumps in social housing in Penwith, Cornwall	D.A.Coley & D Lash	12
547	Guidance on School Indoor Environments	D.A.Coley	8
548	CO2 Emissions from Transport in Torbay	T.A.Mitchell	2
549	CFD Modelling of Shaldon Bridge	D.A.Coley	4
550	Siting Wind Turbines in School Grounds: thoughts on the sheltering effects of buildings	D.A.Coley	8

Number	Title	Author(s)	Pages
551	Daylighting Calculations at Bideford College	D Lash	22
552	The Acoustics and Pattern of Activities in the "Heart" Space at Redbrook Hayes School.	S.F.S. Hunt	3
553	Potential Noise Impact of the Planned Sport Playing Fields at Sir James Smiths Community School, Camelford, Cornwall	U. Winkler	11
554	Assessment of Impact Noise Transfer from Foundation Unit Outdoor Play Area to Key Stage 2 Classroom, Exwick Heights Primary School	T.A.Mitchell	14
555	Biogas as Transport Fuel - Notes from the Biogasmax Friends Meeting on 30/01/2008	U. Winkler	7
556	Stage D Report on Acoustics, BREEAM and Zero Carbon Targets for the new Camelford Community Primary School	S.F.S. Hunt	4
557	The Noise Impact of the New Camelford Community Primary School	S.F.S. Hunt	3
558	Establishing a Theoretical Target Carbon Dioxide Emission Rate for a New University Building	D Lash	8
559	Post-Construction Acoustic Testing in Torquay Girls Grammar School Music and Drama Block	T.A.Mitchell	65
560	Speech Intelligibility in the Heart Space at Camelford Community Primary School	T.A.Mitchell	11
561	Part L2A Submission for Bideford College, Devon	D Lash	111
562	Acoustic Assessment of a Three Classroom Extension to Braunton Caen Primary School (Revised Design)	T.A.Mitchell	5
563	Post-Construction Acoustic Testing in Launceston College English Block	U. Winkler	10
564	An Energy Performance Prediction and Overheating Assessment for ADL2A Compliance in a New Classroom Block at Broadclyst Primary School	S.F.S. Hunt	22
565	Speech Intelligibility in the Heart Space at Camelford Community Primary School: Revised Design	T.A.Mitchell	10
566	Phoenix aerial request (17/3/2008)	D.A.Coley	1
567	Comments on Devon's biomass resource	T.A.Mitchell	10
568	Computer Simulations to Investigate Overheating in the First Floor Corridor at Moretonhampstead Primary School, and the Effects of Mitigating Measures	D Lash	10
569	An Acoustic Assessment of an Extension to Broadclyst Primary School: Revised Design	T.A.Mitchell	6
570	Integrating national indicator 187 into Devon County Council's LAA targets together with the impact of Devon Warm Zones on national indicators 186 and 187	D Lash	4
571	The Projected Impact of National Policy On Devon's CO2 Emissions	S.F.S. Hunt	17
572	Simple Estimates of Future CO2 Emissions in Cornwall for the 2008-2011 Local Area Agreement	S.F.S. Hunt	4
573	Acoustic Assessment of a Lecture Theatre at Dartmouth Community College	T.A.Mitchell	5
574	Noise Impact Assessment of Developments at Montgomery Primary School, Exeter	T.A.Mitchell	9
575	The Effect of Devon County Council's Local Authority Indicator Targets on Transport CO2 Emissions	T.A.Mitchell	3
576	Noise Impact Assessment of Developments at Newton Poppleford Primary School	T.A.Mitchell	9
577	Whole-Building Thermal Modelling of St. Peters, Exeter	D.A.Coley	3
578	Setting CO2 Reduction Targets for Devon's Local Area Agreement using NI186 and Proxy Indicators	S.F.S. Hunt	6
579	Strategic Modelling of Estover College	D Lash	3
580	Acoustic Considerations at Poltair School Phase 3	T.A.Mitchell	4

Number	Title	Author(s)	Pages
581	The Impact of Devon County Council's LAA Targets 2008-2011 on National Indicator 186	D Lash	12
582	Acoustic assessment of Camelford Community Primary School	S.F.S. Hunt	15
583	Noise Impact Assessment of Cranbrook Educational Campus	T.A.Mitchell	12
584	Electricity Saving Opportunities Identified by Half-Hourly Monitoring at Sherwell Valley Primary School, Torquay	U. Winkler	10
585	A Noise Survey of the St Mewan School Site	S.F.S. Hunt	3
586	The Effect of Emissions from Stationary Buses and Traffic in Wesley Street, Camborne	T.A.Mitchell	2
587	An Assessment of Energy Used by Transport in the South West to 2020	T.A.Mitchell	23
588	Assessing the Payback Period of Retrofitting Solar Control Film to Roebuck House, Torbay	D Lash	12
589	A Comparison of the Ventilation Provided by Different Window Opening Options	D.A.Coley	3
590	Further Acoustic Considerations at Poltair School Phase 3	T.A.Mitchell	3
591	Measurements of Electromagnetic Fields, Rennes House, Exeter	D.A.Coley	5
592	Modelling the Impact of Climate Change in Schools: some initial results	D.A.Coley	3
593	Noise Measurements at St. Mewan Primary School, June 2008	T.A.Mitchell	7
594	ELF Magnetic Field Survey for Instow School	D.A.Coley	6
595	The Embodied Energy of Cold Water Supply and Treatment	D.A.Coley	3
596	Some Thoughts on Zero-Carbon Schools	D.A.Coley	5
597	Calculations of Rain Impact Noise at Camelford BSF Primary School	T.A.Mitchell	3
598	Further Rain Impact Noise Calculations for Poltair School Phase 3	T.A.Mitchell	3
599	Some Thoughts on the Government's RE Strategy (Consultation)	D.A.Coley	8
600	Carbon Emission Reductions in the Cornish Road Transport Sector	U. Winkler	29
601	Building a Zero-Carbon School	D.A.Coley	4
602	Response to the Zero Carbon Task Force Call for Evidence	D.A.Coley	24
603	Acoustic Assessment of a Four Classroom Extension to Shiphay Primary School	T.A.Mitchell	9
604	BB93 Assessment of Estover Outreach Centre	D.A.Coley	5
605	Revised Payback Periods for Solar Treatment of Roebuck House: An addendum to Internal Document 588	D Lash	1
606	Post-Construction Acoustic Testing in Grade-Ruan Church Of England Primary School, Cornwall	T.A. Mitchell and U. Winkler	7
607	Post-Construction Acoustic Testing in Newquay Tretherras School, Cornwall	T.A. Mitchell and U. Winkler	10
608	Post-Construction Acoustic Testing in Torpoint & Rame Community Sports Centre, Cornwall	U. Winkler	8
609	Post-Construction Acoustic Testing in Hayle Community School, Cornwall	U. Winkler	9
610	Post-Construction Acoustic Testing in the Design and Technology Centre, Camborne Science and Community College, Cornwall	U. Winkler	9
611	Post-Construction Acoustic Testing at St. Dominick Church of England Primary School, Cornwall	U. Winkler	7
612	Acoustic Assessment of Camelford Primary School (Revised)	S.F.S. Hunt and T.A. Mitchell	16
613	BB93 Compliance Assessment of FSU Extension to Holsworthy Primary C of E School	U. Winkler & T.A. Mitchell	8
614	Acoustic Design Assessment of Dawlish Youth Centre	T.A.Mitchell	15

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