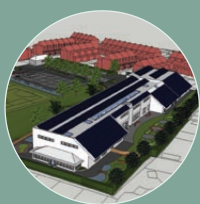
Annual Report 2013

Centre for Energy and the Environment

About SWEEG

The South West Energy and Environment Group is a collaborative research partnership between public sector organisations in the South West which aims to share information and research on energy and environmental issues in the built environment.

As a coordinating member, the Centre for Energy and the Environment (CEE) carries out technical research for the group. All research completed by the Centre is disseminated among SWEEG partners and work of wider interest is published in technical and academic journals. A list of this year's publications can be found at the end of this report. Further details about the Centre and SWEEG are available at www.exeter.ac.uk/cee.

Current SWEEG members

- Cornwall Council
- Devon and Cornwall Police Authority
- Devon County Council
- Exeter City Council
- East Devon District Council
- Mid Devon District Council
- Plymouth City Council
- Royal Devon & Exeter NHS Foundation Trust
- Teignbridge District Council
- Torbay Council
- University of Exeter

Organisations wishing to enquire about SWEEG or commission work from CEE should contact:

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Preface

Resolving the fractures in climate policy

The suggestion that the use of fracking to exploit shale gas reserves can play a material part in the UK's economy is a distraction from tackling climate change.

The IPCC report released on 27th September 2013 reinforced our understanding that climate change is unequivocal and that greenhouse gas emissions from human activity is the cause. We either get to grips with the risks of climate change or see our ability to limit its effects slip from our hands.

Globally populations need to deny themselves access to the remaining fossil fuels, stop emissions through effective carbon capture and storage, or embrace both of these approaches. However, fossil fuels are abundant and there are sufficient reserves on the planet to cause dangerous and irreversible changes to our climate if all of the carbon is released through combustion. The energy industry has proved over many years that it is adept at finding and extracting fresh reserves and the concept of 'peak fossil fuel' is driven further into the future by advancing technology and rising prices.

The OECD Secretary-General recently highlighted Government's deep entanglement with the fossil fuel industry[1]; taxes from oil and gas finance the public sector. In the UK tax inflows from the North Sea rescued the economy in the 1980s and duty on fuel currently raises £30 billion a year. The fossil fuel industry provides jobs both directly and downstream through sectors such as transport. Historic investment in the fossil fuel sector over decades has been vast and profitable; it is estimated that globally £3.75 trillion will be allocated to developing long life fossil fuel assets over the next 10 years.

The combined effect of abundance and entanglement have mesmerised successive governments. It is no wonder therefore that there is a tendency for mixed messages, incoherent and inconsistent decisions, and policies which obscure the pathway to zero net emissions.

The fracking debate in the UK is a good example. The Government has asserted that shale gas is good for the UK and could bring down gas prices based on the experience in the USA. This statement is premature and is both technically and economically flawed. Technically because shale gas wells typically lose 80% of their productive capacity in the first year, and economically because markets need to be deep and liquid to operate effectively.

In the USA shale gas production increased to 7.5 times the 2005 output by 2011, and now makes up over 30% of US gas production. To maintain this rising production profile requires repeated drilling as production withers from the existing wells. In the five years to 2010, one area outside Fort Worth in Texas saw the number of shale gas wells grow from 400 to 10,000. We know that this level of activity is not practical in the UK, even in 'The North'.

North America has the only deep and liquid gas markets in the world. In such markets supply and demand interact freely to set prices and consumers reap the rewards of abundance with lower prices. The European gas market, of which the UK is a part, is different, and increased local production would not materially affect wholesale gas prices: shale gas in the UK will not be a second North Sea. At the margins shale gas might displace some imported gas, but the benefits are minor and the impacts potentially catastrophic if the message that 'gas is good' prevails and the provision of tax incentives for fossil fuel production continues.

Against this background it can be hard for organisations to develop effective strategies around energy and carbon and separate the facts from the misinformation and dogma that all too often proliferate around environmental issues. The SWEEG partnership provides a unique forum for the flow of informed, impartial and objective information between member organisations. For 35 years this exchange has provided clear and consistent messages and evidence to support decision making in the south west.

Tony Norton
November 2013

[1] *'The climate challenge: Achieving zero emissions'. Lecture by Angel Gurria, London, 9th October 2013*

Introduction

This report picks a few highlights from more than 80 projects in which the Centre has been involved over the past year. The extensive workload is a testimony to the continuing needs of SWEEG partners, the success of our other research and teaching activity, and the skill and dedication of the team in providing timely, high quality outputs.

While these highlights give an impression of what the Centre has done, it is a selective snapshot. For example, unlike last year, there are no waste management projects reported although we continue our work in this area by contributing to the development of Devon's emerging Waste Plan.

Within these few pages it is also difficult to convey the role the Centre plays as part of the fabric of the region's collective intelligence on the built environment. Over many years the SWEEG partnership has developed a unique combination of knowledge, expertise, practical experience and personal networks which has enabled the partnership to deliver outcomes which perhaps would not have occurred otherwise.

We are at a critical point with a number of initiatives in the SWEEG region. There has been progress on energy efficiency, renewables, low carbon heat networks, optimal waste resource recovery using CHP and district heating, and we are beginning to understand the implications of SMART systems. In district heating for example, having delivered Cranbrook, the new low carbon community to the East of Exeter, SWEEG partners are looking at the potential for five more large scale district heating schemes. Similar examples exist in the other areas. Either we will move from concept to delivery with these projects over the next few years or the momentum will be lost and the transition to a low carbon economy will be put on hold.

While the messages from Westminster may be mixed as we approach 2015, SWEEG partners have the opportunity to make an important impact.

About the Centre

The Centre for Energy and the Environment has been working with government, local authorities, other public sector organisations and businesses for over 35 years. As a research group within the University of Exeter, the Centre is uniquely placed to provide bespoke research which can help reduce carbon emissions and energy consumption.

Our expertise is varied and covers all aspects of the built environment including:

- Sustainable building design
- Improving efficiency in existing buildings
- Policy in energy, buildings and the environment
- Carbon reduction strategies
- Adaptation to climate change
- Renewable and community scale energy
- Thermal modelling and daylighting
- Acoustic design
- Transport policy
- Waste

The Centre provides access to academic expertise and is active in public and private sector projects. The research ranges from 3 to 5 year Research Council programmes to short applied projects for SWEEG partners, and the Centre can also respond quickly and flexibly to new challenges. The Centre retains a pro-environmental outlook but is impartial and objective in the research it carries out. Contract research and consultancy are also undertaken in both the public and private sectors.

Staff from the Centre also teach within the University and can deliver bespoke CPD training programmes or provide academic supervision for Knowledge Transfer Partnerships with industry.


Meet the team

Tony Norton *Head of the Centre*

Tony Norton is the Head of the Centre for Energy and the Environment; he is a Chemical Engineer with a background in the international energy industry. His experience of the economic and commercial issues around energy provision is extensive and includes policy advice to government. Tony's work at the Centre includes the energy aspects of local planning and the development of CHP and heat networks.

Dan Lash *Senior Research Fellow*

Dan studied architecture at the University of Sheffield and now specialises in low energy building design, including natural ventilation, thermal performance and comfort, and maximising natural light. His expertise extends to design reviews, strategic planning, and area assessments for energy and emissions. He is also a CIBSE Low Carbon Energy assessor, accredited Passivhaus designer and a BREEAM schools assessor.

Andrew Mitchell *Research Fellow*

Andrew has more than fifteen years' experience in monitoring the environmental performance of buildings. He has evaluated performance against expectations and results have been used to manage energy consumption and inform future building designs. He also specialises in acoustics, air quality management and transportation. He is a member of the Institute of Acoustics.

Tristan Kershaw *Research Fellow*

Tristan is a physicist who specialises in the thermal modelling of buildings and adaptation to climate change within the built environment. He is currently working on the European FP7 funded project UMBRELLA, which is developing a toolset to enable stakeholders to optimise a building design in terms of energy efficiency, carbon emissions, comfort or in-use costs. Importantly, the tool will consider buildings over their whole life cycle .

Andrew Rowson *Associate Research Fellow*

Andrew is an engineering mathematician with a background in construction, engineering and computer modelling. He currently specialises in renewable energy technologies and policy. He was project coordinator for the IEE funded project FOREST which supported biomass heating through the adoption of best practice and deeper supply chain integration.

Matt Eames *EPSRC Research Fellow*

Matt is working on an EPSRC project focused on early stage building models and the prevention of overheating within buildings. His main interests are building model optimisation, estimating the impact of climate change on the built environment and models to describe heat stress within buildings. Matt's expertise has seen him working with CIBSE on the limitations of existing methods for representing extreme weather in the summer.

Mike Wood *PhD student*

Mike has carried out research and consultancy into all aspects of sustainable building. His areas of expertise include acoustics, thermal performance and building monitoring; he is also a member of the Institute of Acoustics. Mike is in the first year of a PhD looking at early stage building models with Matt Eames where he is finding novel ways to drastically shorten the time it takes to model the thermal performance of buildings.

Edward Shorthouse *PhD student*

Edward has a degree in Physics and Philosophy and as a former manager of National Trust properties he gained a professional interest in the built environment and the requirements of building development within heritage and special interest sites. He is currently in the second year of a PhD with Matt Eames looking at overheating in buildings, particularly during extreme weather and future heatwaves.

Policy and Planning

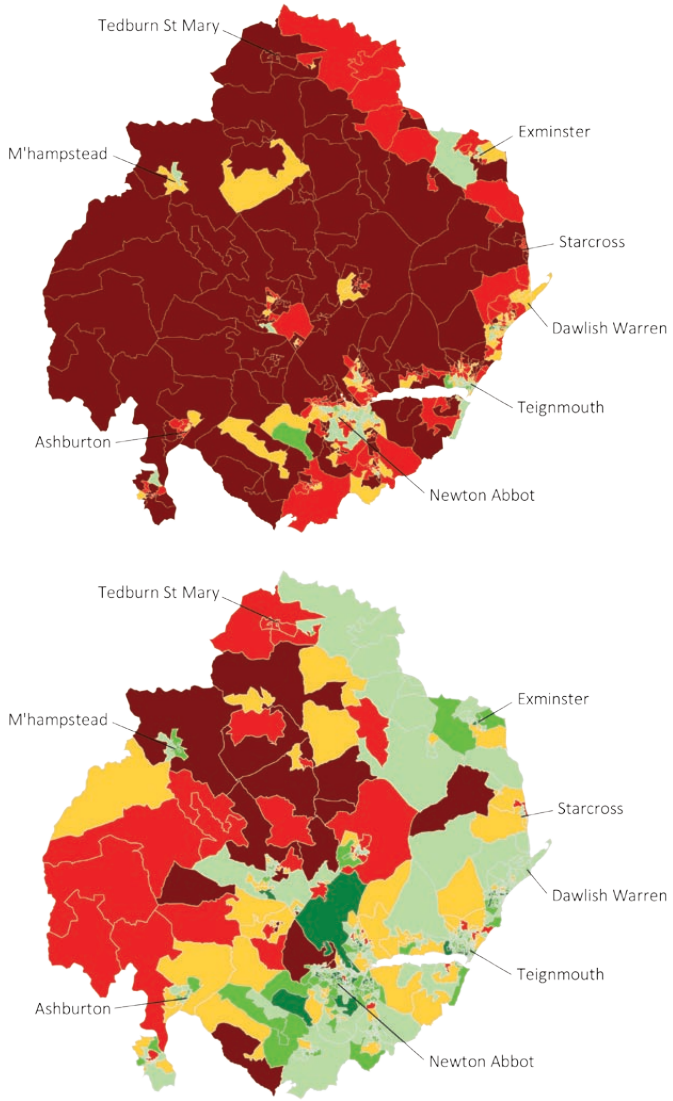
The Centre continues to be involved in energy and carbon planning through the development of strategic planning policies, analysis of Government policy, and advice on individual schemes via local planning authorities and expert review panels.

Teignbridge District Council Local Plan Policy

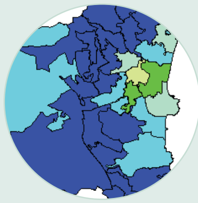
Teignbridge District Council's draft Local Plan contains an aspiration for a 42% reduction in carbon emissions within the district by 2030. The Centre was commissioned to develop a method to support the headline policy by appraising the potential emissions from new developments.

Typically energy and carbon standards for new developments concentrate on making improvements to the requirements of Part L of the Building Regulations. The innovative solution developed for Teignbridge still captures emissions from homes, but also includes those from transport, and makes some additional allowances for the commercial sector. The calculation method includes emissions from Part L of the Building Regulations but also considers the impact of generating renewable energy, emissions from white goods, the effects of smart metering, and a host of transport measures including public transport, cycling, home working and electric vehicle infrastructure.

This unique approach enables developers to trade-off carbon performance across a range of design factors. Developments located in more sustainable parts of the district, for example those with good connections to the public transport network, might be required to make fewer additional improvements compared to those located in more remote areas. In addition, the method includes an 'Allowable Solutions' type mechanism where emissions from a development could be offset with investment in carbon reduction measures elsewhere within the district. Meeting the policy requirements would therefore be technically possible on any site, and developers would have considerable freedom in selecting measures that were economically and practically feasible for a given site. The method would be implemented using a very simple spreadsheet type calculator, which would ensure an efficient and consistent application of the policy.



Carbon emissions per person for hypothetical developments in Teignbridge which just meet Part L of the Building Regulations (top), and for a moderate improvement on Part L combined with additional transport measures (bottom). Areas that meet the proposed policy are shaded in green. In order to meet the policy, any areas shaded yellow or red would either need to improve the energy performance of the development further or offset emissions using an "Allowable Solutions" mechanism.

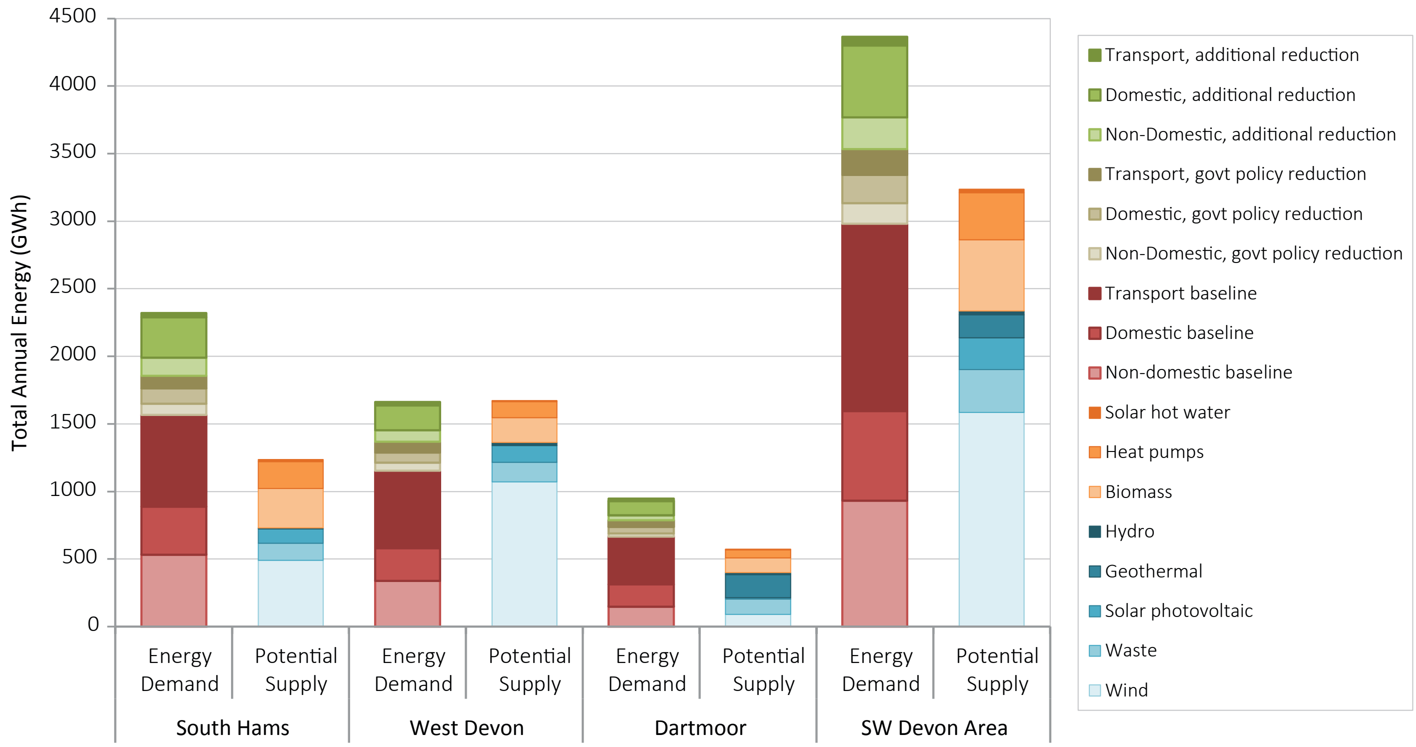


South West Devon Community Energy Partnership Evidence Base

The South West Devon Community Energy Partnership (SWDCEP) comprises local authorities, community groups and specialists in the south west area of Devon. Geographically, it covers the districts of South Hams and West Devon, together with Dartmoor National Park. The Centre was successful in winning a tender to produce an evidence base for the partnership to help understand energy demand in the area, together with opportunities to reduce demand and to improve energy resilience by increasing generating capacity locally.

The analysis, using multiple data sources and GIS mapping techniques, established that energy spend in the south west of Devon is about 20% of the economic output of the area, the equivalent of about 15,000 jobs. Initial estimates of energy use across the domestic, non-domestic and transport sectors considered the impact of growth and the anticipated effect of Government policies. Alongside this, a series of demand reduction measures were modelled in each of the sectors to establish the overall potential for reducing energy demand. Measures included improvements to buildings such as insulation, and transport measures such as modal shifts and car sharing. In parallel, a renewable energy resource assessment was produced for the area, which drew on a number of existing resources.

Analysis of the compiled data identified eight priority areas where the partnership should concentrate its efforts and a basis on which to develop relevant action plans. Findings from the study were disseminated at several events, including a Councillors' briefing session and the Grand Launch of the SWDCEP Partnership at Devon County Hall.



Total energy demand and supply in south west Devon and in the sub-areas within, showing potential for demand reduction and energy supply resulting from measures identified within the study. The red coloured bars in the demand columns represent a baseline in non-domestic, domestic and transport energy use once all demand-side measures have been implemented, while green bars indictate scope for demand reduction. All regions have the potential to meet a large proportion of their demand through local generation.

Sustainable Buildings

Adapting Buildings to Climate Change

Through the EPSRC funded PROMETHEUS project, scientists at the Centre developed climate files that have been used to model over £3 billion of construction projects.

The ESI Building at the University of Exeter Penryn Campus, Cornwall

The Centre continues to be a leader in this field and has been involved in 5 of the 48 *Design for Future Climate* projects. Funded by the Technology Strategy Board, these projects have analysed the performance of the buildings under various climate change scenarios to understand issues around comfort, energy consumption, water demand, flooding and ecology.

The latest buildings to be considered are a swimming pool in Exeter, an office block and the Environmental Sustainability Institute (ESI- pictured above) at the University of Exeter's Penryn Campus in Cornwall. In each case the Centre has provided architects with detailed thermal modelling to inform the design process and a series of intervention and adaptation plans.

The office block was modelled to Passivhaus energy efficiency guidelines which will maintain thermal comfort over the life of the building without the need for air conditioning. The benefits of this approach were also able to be quantified in terms of the productivity of the workers.

At the ESI an ensemble of passive measures were implemented to mitigate the risk of overheating both inside and outside the building. Similarly, over-sizing the rainwater harvesting tank and the capacity of roof outlets were shown to be an effective way to minimise difficulties with the supply of water, and planting a diverse mix of species is seen as the best approach to preserve the landscape and ecology.

The accompanying adaptation plan included 'trigger points' which demonstrated a lifetime financial saving of around 2% compared to acting reactively to changes in the climate (for example being forced to roll out air conditioning). The ESI has gone on to win Eco Building of the Year in the Michelmores/ Western Morning News Property Awards 2013.

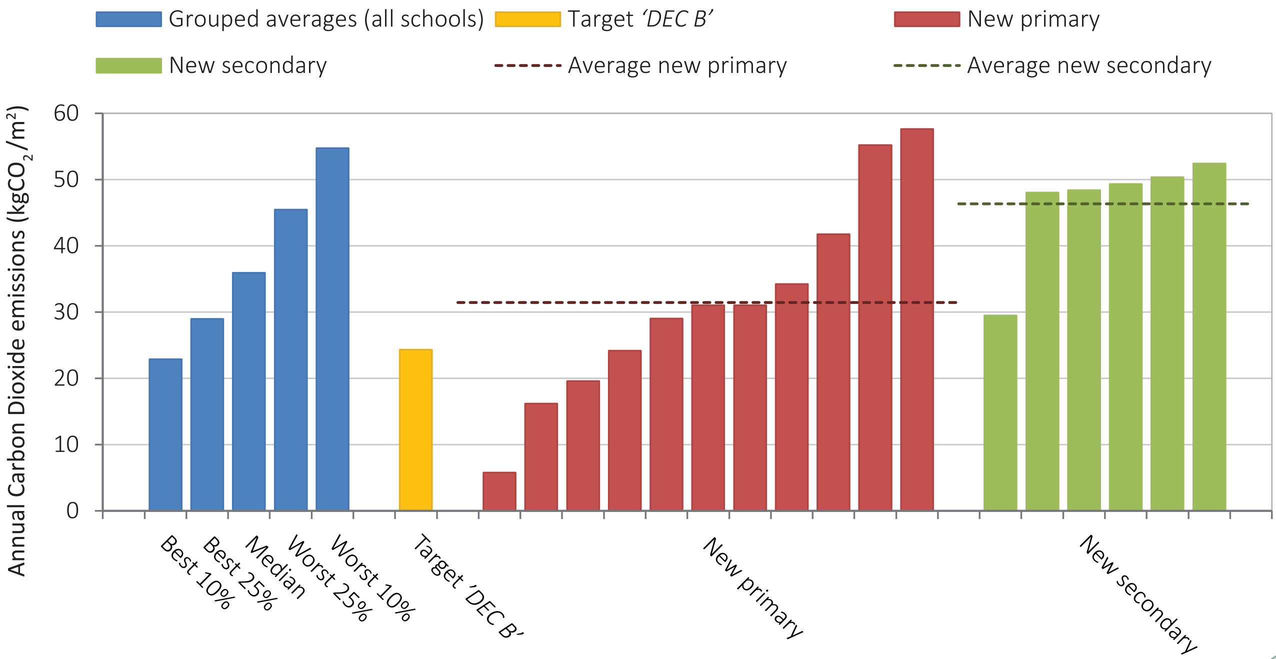
Improving Building Standards

The Centre is using its knowledge and experience of buildings to help Local Authorities to close the gap between design and 'in-use' performance.

Devon County Council has developed a design standard for new school buildings. As part of this process there was a requirement for new designs to provide value for money, both in terms of capital and running costs. Excessive energy use results in unnecessary expenditure for a school over the life of the building and increases its carbon emissions.

Currently the energy performance of new buildings is legislated through the Building Regulations, but it has been shown that there is a clear and significant gap between the theoretical calculations undertaken to demonstrate compliance and the actual in-use energy performance of a building. It was therefore proposed that the emerging specification should be developed to target an in-use energy performance standard. The target chosen was a Display Energy Certificate (DEC) 'B' rating. All buildings over 1000 m^2 are required to produce DECs which are rated between A and G based on metered energy over a 12 month period. Achieving a 'B' rating would place a school in the top 14% of schools in the county. Taking this approach would result in lower carbon emissions than has been experienced on average for new schools in Devon and, for an average size school, would result in annual energy savings of approximately £6,000 per year.

Analysis was undertaken using a series of calculation methods to provide a more robust estimate of carbon emissions than those used in the Building Regulations. A range of minimum performance standards were presented for incorporation into the specification and the approach was later trialled during the design process of the Rushbrook Centre in Totnes. Interestingly new industry guidance on predicting in-use energy performance *(TM54: Evaluating operational energy performance of buildings at the design stage)*, which was published after this piece of work, adopted a very similar approach to the work undertaken by the Centre for Devon County Council.



Carbon emissions from all existing Devon schools (blue series), the proposed new in-use standard (yellow), and selected new primary and secondary schools (red and green respectively). The average in-use emissions from these new schools are denoted by the horizontal dotted lines.

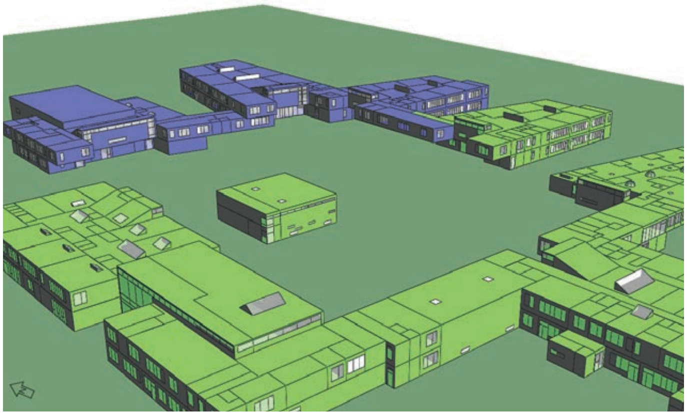
Building Modelling and Design

Computer modelling of building performance has long played a central role in the work of the Centre. Back in the mid 1980's the Centre developed 'EXCALIBUR', one of the first dynamic thermal models based on networks of resistors and capacitors.

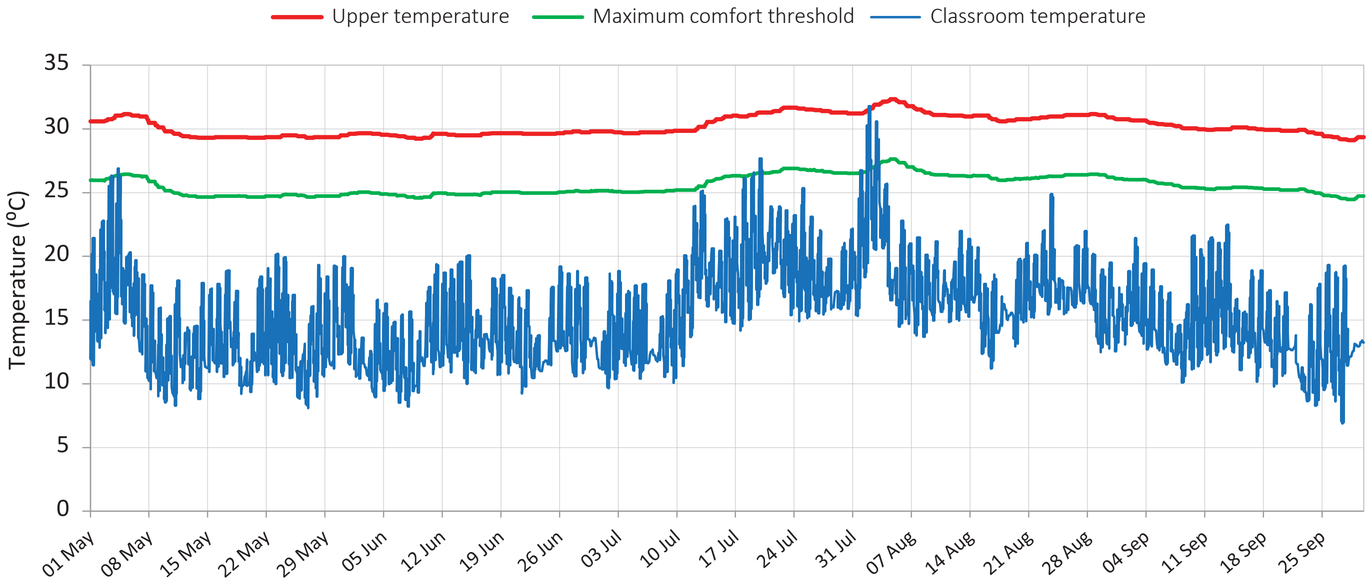
Work in this field is continuing through a 5 year EPSRC fellowship which is creating new thermal models for designers, and through the FP7 funded UMBRELLA project, which will use thermal models to inform building design based on stakeholder preferences.

The Centre has applied its thermal modelling expertise on numerous real building projects this year including Mill Water School, Ladysmith School, Sidmouth College, Withycombe Raleigh School, the Rushbrook Centre and the Knightley Building at the University. These studies have been undertaken at the early stages of design or refurbishment, with the aim of iterating towards solutions which are both comfortable for building occupants and can demonstrate low demand for energy.

Recently, new guidance for assessing overheating risk in buildings has been published by CIBSE *(TM52: The Limits of Thermal Comfort: Avoiding Overheating in European Buildings)*. The Centre has been quick to implement TM52 on real world projects and key lessons on the similarities and differences between TM52 and previous standards have been learnt, although the established principles of sustainable design, including high levels of insulation, appropriate thermal mass and effective ventilation regimes, remain as relevant as ever.



Computer model of Tor Bridge (above) and simulated temperatures in a classroom (below) over the summer period (blue line) together with moving adaptive temperature thresholds. The green line is the maximum comfort threshold, which may be breached for a small proportion of the year, while the red line indicates the upper allowable temperature.



Monitoring Buildings

Post occupancy monitoring projects have been completed at Bideford College and Montgomery Primary School, two high profile, low energy buildings where the Centre has provided modelling and guidance on design for future climate scenarios.

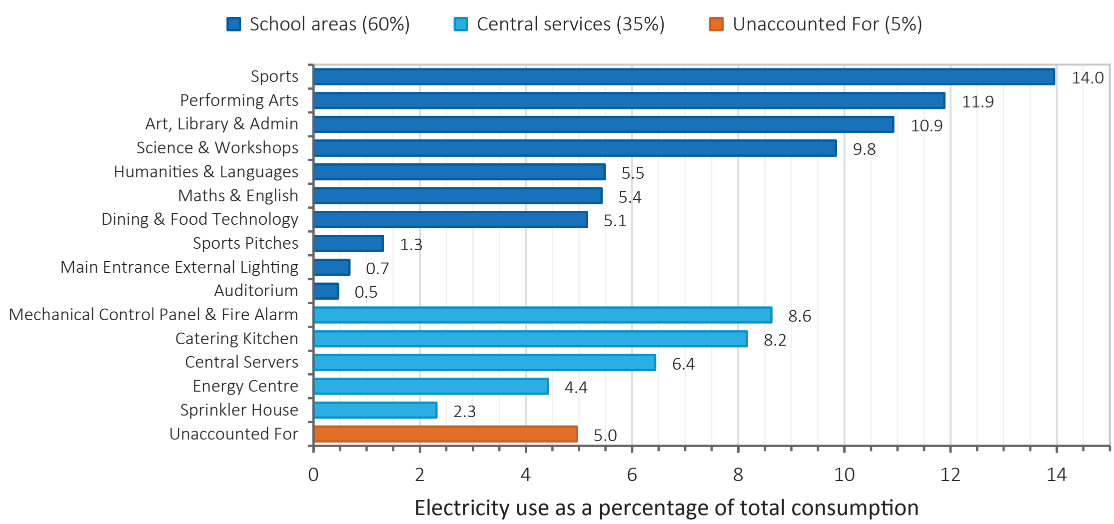
Montgomery Primary School is the first Passivhaus School to be built in the UK and has just been shortlisted for the CIBSE Building Performance Awards 2014. The Passivhaus Standard helps address future climate change with high quality building fabric and extremely low energy requirements. Data from a year of monitoring has now demonstrated that primary energy consumption at Montgomery is lower than the average for schools, additional heating is reduced to a bare minimum and the annual electricity consumption is closely matched to the output of the school's 160 kW_p photovoltaic system.

Montgomery and Bideford have both demonstrated low heating requirements, but electricity consumption was above average, due in part to the high level of IT provision. Carbon emissions at Bideford were close to the per pupil average but, the use of unconditioned spaces means that per unit of floor area they are relatively low. The use of best practice equipment means that water consumption per pupil is below average at both schools.

At both sites difficulties were identified with the design and commissioning of sub metering. Correctly implemented sub metering can reveal interesting trends and is an important tool in energy management. Significant electrical baseloads (overnight consumption) were identified at Bideford, sometimes amounting to 30% of the peak load, while at Montgomery baseloads were found to be high in the plant room and some teaching areas. Understanding these loads is an important first step in reducing unnecessary consumption.

The Centre has also undertaken further monitoring work at Tor Bridge High School in Plymouth for the Technology Strategy Board. The school is part of a new campus in Estover which includes a primary school, nursery and special school, and was built as part of the *Building Schools for the Future* programme.

Monitoring of electrical supplies has been used to verify and supplement permanently installed sub meters and provides a clear picture of electricity consumption. The load from certain centralised systems (IT servers and plant) has been shown to be considerable (see below). Shortcomings have also been revealed in the sub metering and building management systems, resulting in consumption which was not able to be accounted for. The systems are now recording large quantities of data which will continue to inform the project. Other activities have included an assessment of the biomass system and detailed ventilation analysis for a sample of rooms.



A breakdown of the energy consumption derived from sub metering at Tor Bridge. The load from central services is relatively high and unaccounted consumption has been reduced from 40% at the start of the project to around 5%. Given the uncertainty associated with deriving energy consumption from measured electrical current, this is a good result.

Automatic Meter Reading

The Centre has been instrumental in the implementation of sub metering across the Streatham and St. Luke's Campuses at the University of Exeter.

The project which was funded by the Higher Education Funding Council for England (HEFCE) has provided real time monitoring and data logging facilities for energy and water.

This year has seen the system being rolled out into new buildings and interfacing with dashboard displays which can be accessed from computers on the network. As well as contributing to energy management on the site, data from the project has been used to inform a series of sustainability reports that were commissioned by the University and to quantify the carbon footprint of the Business School as part of its commitment to PAS 2060, the Publicly Available Specification for the demonstration of carbon neutrality.

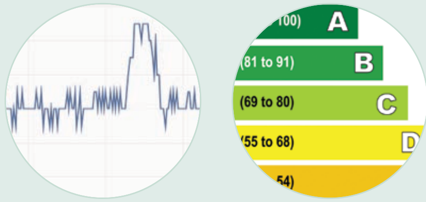
Acoustic Consultancy and Design

Acoustic design and remediation continues to be a core capability within the group. Building regulations require that all school refurbishment and extension projects must comply with minimum standards.

Circulation space at Montgomery Primary School showing elements of good acoustic design including acoustic 'rafts' in the ceiling, carpet and soft furnishings.

A wealth of studies have shown the detrimental effect of noise exposure on educational outcomes, and the ability of the youngest students to recognize speech sounds suffers particularly, even in the presence of modest levels of ambient noise.

Acoustic surveys have been undertaken for the Rushbrook Community Hub and primary schools in Exminster, Newton Abbot, Broadclyst and Bideford. Guidance was given on details of the designs which will help them to achieve compliance with the regulations. Site investigations and remedial noise strategies have also been developed for a crematorium and a residential barn conversion.



Energy Efficiency

Energy Efficiency Refurbishment at the RD&E

The Royal Devon and Exeter Hospital commissioned the Centre to assess the energy consumption at the Wonford site and review opportunities for reducing energy consumption.

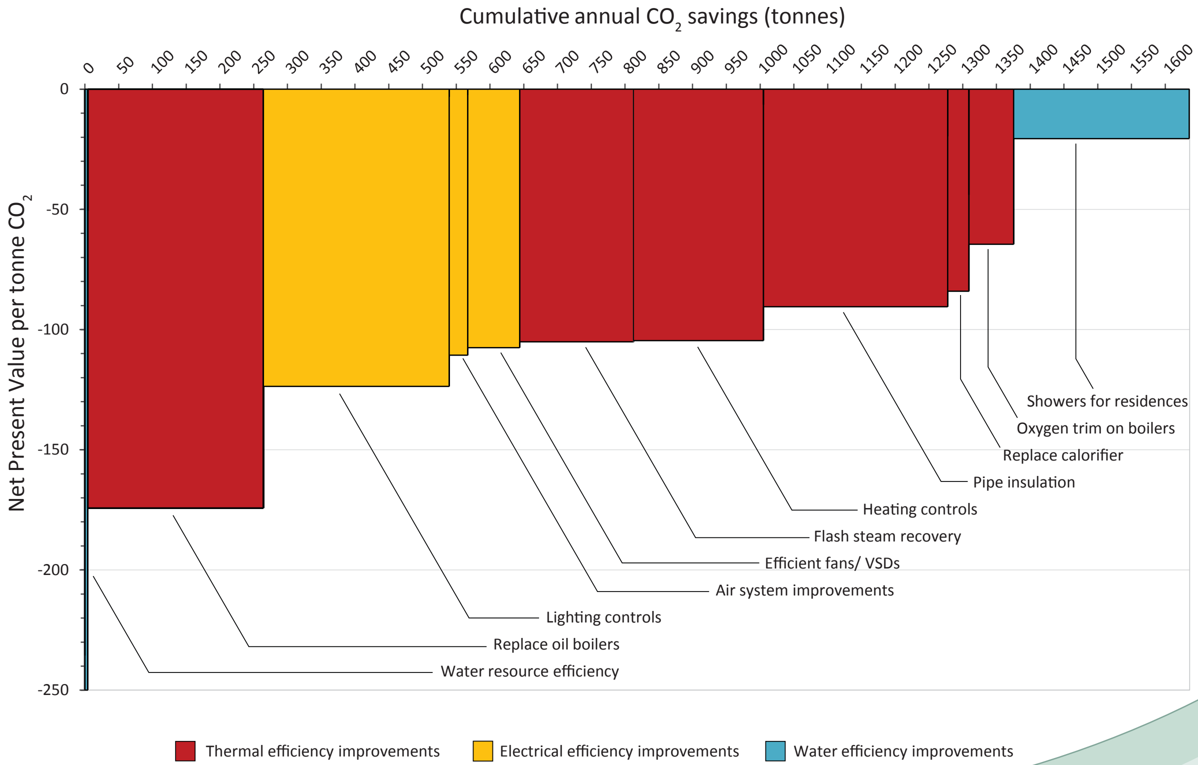
A key part of the work was to identify capital projects and help to structure an application for the Department of Health *Carbon and Energy Efficiency Fund*. The fund is competitive with projects expected to lead to a 'step change' in energy efficiency, demonstrate recurring benefit, contribute to the NHS carbon saving target and improve the quality of the overall environment for patients, visitors and staff. The fund targets capital measures only with an expectation of a return on investment within four to five years.

The Centre based its analysis on energy data from the hospital combined with NHS guidelines which were adjusted using recommended scaling factors relevant to the Wonford site. A discounted cash flow analysis was performed on a range of suitable efficiency measures and the results compiled as a marginal abatement cost or MAC curve (see below). The suite of measures that was eventually selected is estimated to deliver annual CO_2 savings in excess of 1,600 tonnes and should give a payback in a little over three years.

The analysis was submitted to the Department of Health as a key part of the funding application and was eventually rewarded with a £1.1 million grant to implement the measures.

The impacts of the improvements are to be verified as a condition of the funding and the Centre is working closely with the hospital to implement a monitoring regime which will provide the relevant data. The final results will be of interest to other SWEEG members considering similar efficiency upgrades.

The MAC curve shows individual carbon saving measures as bars of variable widths to represent annual CO_2 savings. The height of each bar gives the associated cost per tonne to achieve these savings, with negative cost values indicating measures which should provide a financial return.



Energy Efficiency in the South West's Homes

As part of the 2011 Energy Bill, the Coalition Government announced that the Home Energy Conservation Act (HECA) would be repealed. However, by the end of the year this decision was reversed.

HECA requires every UK local authority with housing responsibilities to produce an energy conservation report that identifies practicable and cost effective ways to improve the energy efficiency of all residential accommodation in their area and to report on progress. In July 2012 the Department of Energy and Climate Change (DECC) issued new guidance for local authorities to prepare reports under the act, with the first report due by 31 March 2013.

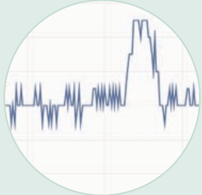
Unsurprisingly, the new report focused on the Coalition's flagship energy efficiency policy, the Green Deal and Energy Company Obligation (ECO). The Centre provided support in compiling HECA reports to nine local authorities in the SWEEG region and published a regional database summarising the relevant data for the former GOSW Region at lower level super output area and district authority level. The database is free to download from the Centre's website *(see www.centres.exeter.ac.uk/cee/resources/heca/index.html)*.

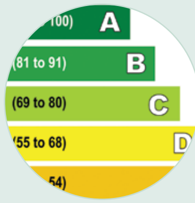
There are many different types of homes in the SWEEG region and the associated energy efficiency issues vary widely. The historic nature of much of the housing stock leads to a high incidence of 'hard to treat' solid wall properties *(top right map)*.

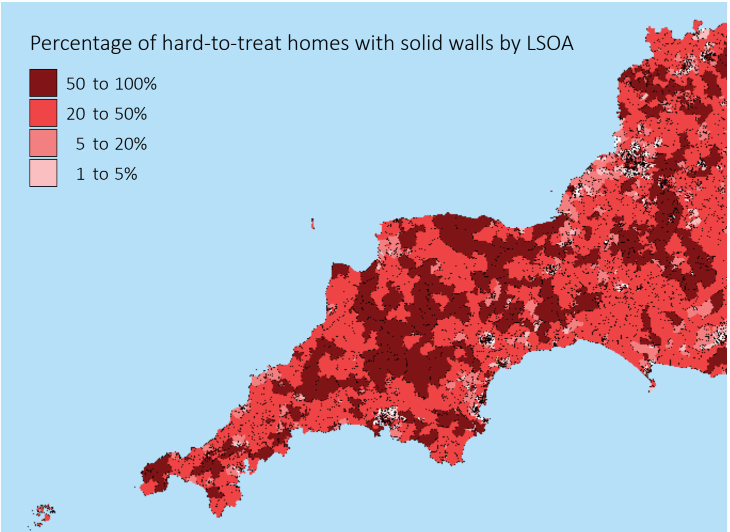
Many of these homes are also in areas without access to mains gas and reliance on oil, LPG or electric heating is common *(middle right map)*. The combination of poorly insulated properties with relatively expensive heating can compound the problem of keeping homes warm in these areas.

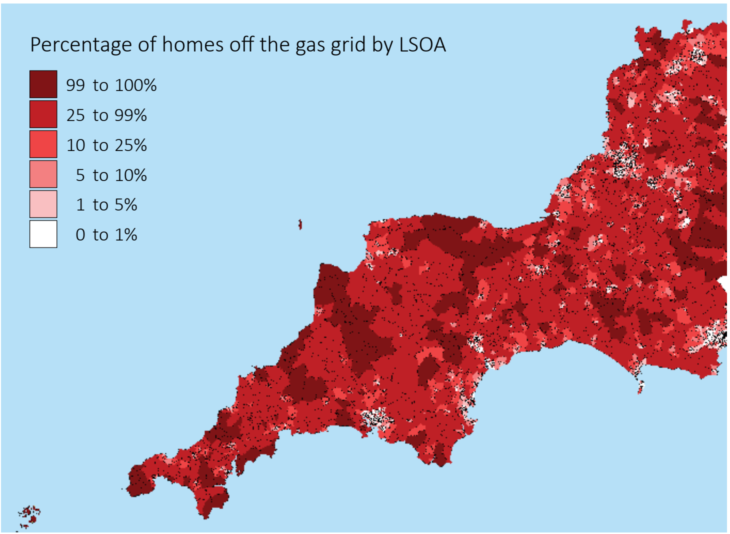
When these figures are combined with data on incomes the widespread incidence of fuel poverty across the region becomes apparent *(bottom right map)*. In some areas over 30% of homes are spending more than 10% of income on fuel. This particular measure of fuel poverty has since been replaced as a result of the Hills Review *(Getting the measure of fuel poverty, Final Report of the Fuel Poverty Review by John Hills)*.

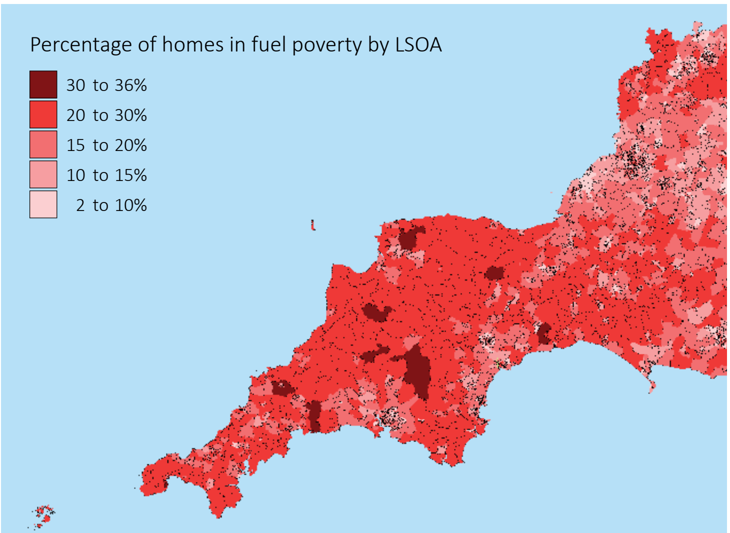
Many cities, towns, and villages in the south west are characterised by 'hard to treat' properties







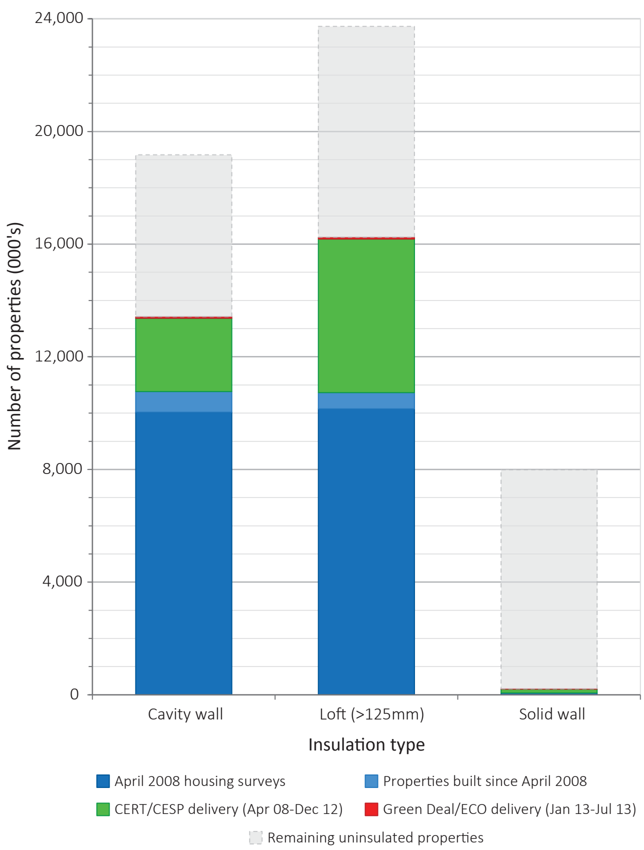




The Green Deal and ECO were just starting at the time of the project and as of March 2013 no data on the effectiveness of the new policies at delivering energy efficiency improvements were available. The Government's own impact assessment was not encouraging. DECC estimates suggest that in the first six months of 2013 there were 50,000 cavity wall and 60,000 loft insulation measures installed in Great Britain under the Green Deal and ECO (these were almost exclusively delivered under the ECO as only one home was listed as having a live Green Deal plan at the end of June).

By way of comparison the previous Carbon Emissions Reduction Target (CERT) programme, which the Green deal has replaced, ran for five years and saw 520,000 cavity walls filled and 1,090,000 lofts insulated annually (see below).

This should be a considerable cause for concern in the south west region where energy efficient retrofit measures are badly needed.



Voltage Management

The Centre reviewed the theory of voltage management for Cornwall Council to see how and where the technology might achieve energy savings. The study also considers an existing voltage management system installed at a local leisure pool.

Voltage management covers a range of techniques and generally seeks to reduce voltage to a fixed value or by a percentage, but it can also provide voltage conditioning or power factor correction. The energy saving claims made by some manufacturers however are extravagant and are not necessarily achievable.

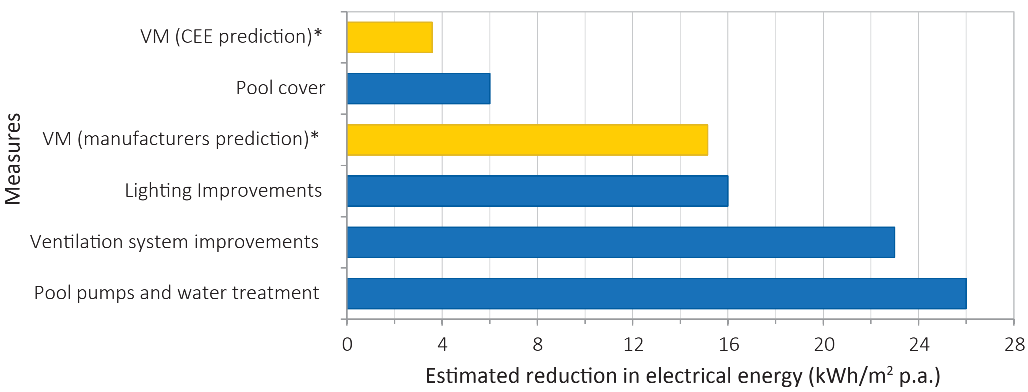
The energy saving principle of voltage management is relatively simple: power (the rate of energy consumption) is proportional to the square of the applied voltage, so a 1% decrease in voltage leads to a reduction in power of almost 2%. However, this simple relation only holds for DC circuits and purely resistive loads; in practice buildings also include reactive loads which cause a phase shift between voltage and current so that the simple relation between power and voltage no longer holds.

The extent to which a site will see energy benefits from voltage management is dependent on the profile and types of loads present. An extensive site survey is required before any savings can be quantified and some voltage managed loads (induction motors, older T12 light fittings, incandescent bulbs) can suffer in terms of performance (reduced torque, lower light output).

While the technology can be effective for resistive loads (e.g. space and water heating), those with thermostatic control take longer to heat up so energy saving potential is minimal. Other loads such as high frequency or LED lighting, IT equipment and variable speed drives are independent of the applied voltage and energy consumption will not benefit from voltage management. In some cases the plant and equipment which can benefit most are those which are probably scheduled for upgrading or replacement, and should be considered as a first option.

At the Bude Splash Leisure Pool, the manufacturers of the voltage management system had guaranteed savings of 7.2% (£2,440 p.a.) for a 4.3% reduction in voltage across the site. While the pool had seen some reduction in energy consumption, this was seen to be closely correlated with a fall in visitor numbers and the effect of the installation was hard to separate from other potential causes. The Centre analysed electrical loads in accordance with a methodology prescribed by the Carbon Trust. Estimates of savings require knowledge of the extent to which individual loads are voltage dependent, and on a complex site this is far from clear. Instead a model was developed to test the probability of energy saving for all scenarios within prescribed confidence intervals. The Centre estimates that savings in the order of 1.55% to 1.75% (£545 to £625 p.a.) are more likely.

Recommended 'good practice' measures at the site (e.g. better control of fans and pumps, lighting, use of pool covers, reduction of night time baseload) might be expected to produce electrical energy savings of 42% and it is worth noting that as voltage management provides a percentage saving, the move to these best practice consumption levels would reduce its cost effectiveness. In practical terms this would put the savings from voltage management on a par with lighting upgrades in the best case scenario, while in the worst case more savings would be had from the pool cover *(see below)*.



** Savings from VM assume that recommended 'good practice' measures are adopted first*

Transport

Local Transport Planning

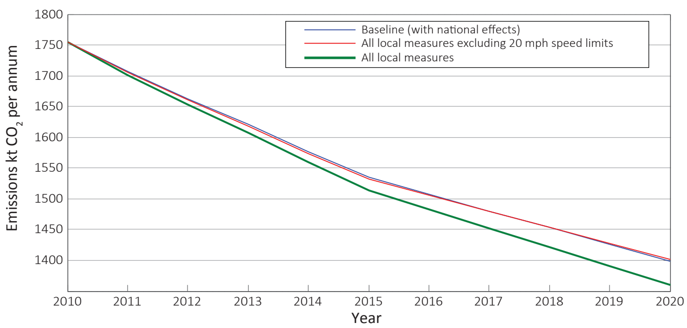
The Centre's past involvement with the modelling and forecasting of road transport emissions in Devon has continued with an assessment of the Third Round Local Transport Plan (LTP3) on carbon emissions.

The underlying transport model developed previously was revised to incorporate the latest available data, both for local transport activity and national technology forecasts.

National policies are forecast to reduce transport emissions by about 9% between 2011 and 2016, while in Devon a reduction of almost 12% is expected due to differences in traffic composition and road type. Four key LTP3 measures were modelled:

- Smarter travel (including park and change sites, and the Cycle Exeter scheme)
- Ecodriving measures
- Car sharing
- The introduction of 20 mph speed limits in urban areas.

The combined effect of these measures, however, was predicted to have a negligible effect compared to total carbon emissions, which were estimated to be in the order of 1500 kt CO_2 per annum for the 2016 baseline year *(see below)*.



Emissions Trajectory for Devon (Excluding Plymouth and Torbay)

The introduction of urban 20 mph speed limits was forecast to increase emissions through worsening fuel economy (although in practice some routes might experience a reduction in traffic). Without the implementation of urban 20 mph speed limits, the local measures might be expected to achieve an additional emissions reduction of around 1.3%, or approximately 20 kt CO_2 per annum, on top of those attributed to national policy measures. As well as the analysis, the Centre has also provided guidance on monitoring strategies to evaluate the level of uptake and impact of these measures on carbon emissions.

Provision of electric car charging infrastructure could help new developments to achieve carbon compliance under a proposal developed by the Centre for Teignbridge District Council.

Transport has also featured as an important part of the Centre's work to provide a carbon assessment tool for new developments in Teignbridge, in connection with proposed Local Plan policies. The tool assesses emissions from residential developments, including the effect of providing facilities for home working, electric car charging and cycle storage, as well as ensuring good access to public transport. Spatial variations in domestic travel patterns were also incorporated using national census travel to work data as a proxy. It was necessary to disaggregate published district authority transport statistics by vehicle and road type so that emission reductions from the above measures could be calculated. The inclusion of transport emissions is innovative in this type of assessment; carbon compliance targets are often based on building and fabric specifications as detailed in Part L of the building regulations, so the proposed methodology provides developers with a wider range of options to enable them to achieve compliance.

Renewable Energy

District Heating and CHP

District heating in Exeter took a major step forward in 2013 with the publication of the Exeter Energy Network Study (supervised by the Centre), and our feasibility study on utilising heat from the Marsh Barton Energy from Waste (EfW) plant.

Extract from the South West Exeter Masterplan by LDA Design on behalf of Teignbridge District Council

A district heating system consists of a central heating plant or energy centre connected to a network of heavily insulated underground pipes which send hot water into homes and other buildings. Heat is extracted from the network by small heat exchangers in each building which allow individual control of heating and hot water. The cooled water is returned to the energy centre by a separate loop where is it re-heated.

Retrofitting of district heating can be expensive but it is common elsewhere in Europe. The potential benefits are such that it is becoming more widespread in UK cities, including Southampton and Birmingham. The Exeter study shows that a scheme which incorporates the larger public sector heat loads across the city is potentially viable; this would include the Royal Devon and Exeter Hospital and the St Luke's Campus of the University of Exeter, as well as other buildings in the city centre.

Heat for the network could be provided either by a gas combined heat and power (CHP) unit located at the hospital, or from the EfW plant under construction at Marsh Barton.

The South West Exeter urban extension straddles the boundary between Exeter and Teignbridge and comprises a large mixed use development of 2,475 homes and over 100,000 m^2 of non-domestic buildings. Both local authorities have adopted draft core strategies or local plans which promote low carbon new development, which is in line with national policies that require all new homes to be zero carbon by 2016; the standard will apply to non-domestic buildings built from 2019.

An assessment of the buildings and the programme for South West Exeter shows that the development, when it is fully built out, will use some 18,100 MWh of heat. Accounting for heat losses through the network, the total heat demand is likely to be 20,000 MWh.

The Centre's economic analysis shows that a district heating network using heat from the Marsh Barton EfW plant is a viable low carbon heating solution for the South West Exeter urban extension, and can achieve annual CO_2 savings of 3,500 tonnes a year. This is equivalent to an 80% reduction in emissions from heat compared to individual heating solutions using gas.

Once emissions from electricity use regulated under Building Regulations are included, the overall emissions reduction achieved in homes is 66%; this comfortably exceeds the upper level allowed for on-site CO_2 carbon compliance which stands at 57%. With the heat network in place, there is also the possibility of increasing the proportion of renewable heat in the system, which may be an attractive alternative to the 'Allowable Solutions' route which would otherwise be needed to achieve a zero carbon outcome.

The Business Case for Photovoltaic Panels across a Large Site

The Centre has undertaken analysis to understand the business case for rolling out PV at a range of scales across the Streatham Campus at the University of Exeter.

The University of Exeter's main Streatham Campus contains approximately 50 academic and administrative buildings, and a further 30 residential buildings. Previous work by the Centre had identified the potential for approximately 1.6 MW_p of building mounted photovoltaic panels (PV)

In recent years there have been significant increases in the rate of PV installations due to the Government's Feed-In Tariff (FIT) scheme. The scheme provides owners of eligible technologies, including PV systems, with a tariff for every unit of electricity generated, and an additional tariff for every unit that is exported to the grid (currently 4.5p per unit). The 'avoided' cost of imported electricity is higher than the export tariff so there is often an additional incentive to consume the majority of the energy generated on site.

The generation tariff is dependent on the declared net capacity for a given site, and decreases for larger installations. However, the definition of a 'site' for the purpose of FITs is potentially complicated, depending on postcode, grid reference and, critically, the fiscal metering arrangements. The University's Streatham Campus, in common with similar campus style sites has a single main metering point, which means that the generation tariff would be calculated on the basis of the total installed capacity for the whole site rather than the size of installations on individual buildings. The cost implications are significant with tariffs ranging from 14.9p/kWh for installations up to 4 kW_p, down to 6.85 p/kWh for installations over 250 kW_p.

The business case for widespread PV deployment is influenced by other factors including the capital cost of panels, installation costs, interest rates, and the energy efficiency of the building where panels are installed, and a series of scenarios were developed to capture these effects. In general terms capital costs were the most significant governing factor, although installing PV with reasonably low installation costs on energy efficient buildings should result in broadly favourable financial returns.

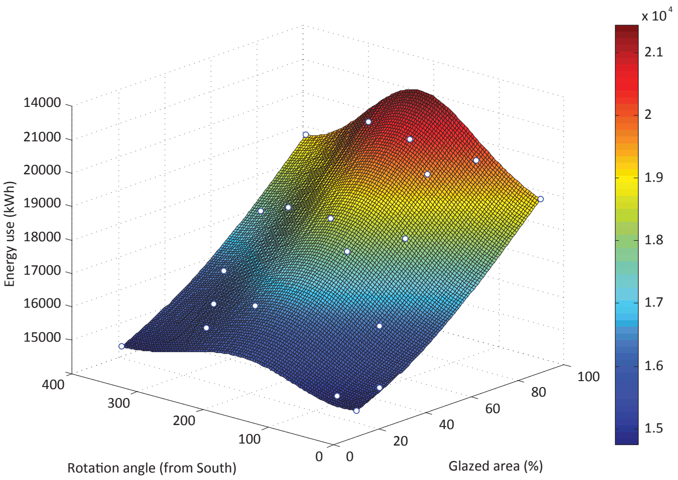
A recent analysis of building performance across the campus identified a large number of projects which were likely to be cheaper and have a greater impact on emissions. For example, the estimated cost of installing 1.6 MW_p of PV across the campus was between £1.4 and £4.4 million and would save around 675 tonnes of carbon dioxide a year, or approximately 3% of the University's total carbon emissions. By contrast, a series of efficiency improvements identified at a large science building would cost in the order of £130,000 and save over 700 tonnes a year. It was therefore suggested that the lower cost, higher return, efficiency orientated projects should be prioritised ahead of large scale PV deployment.

There are a number of south facing buildings and flat roof spaces at the Streatham Campus with the potential to accommodate PV although not all of the sites identified would be considered suitable. The roof structure has to be able to withstand static and dynamic loads without compromising the integrity of the roof fabric. Contrary to popular belief PV is not 'maintenance free' and regular inspection and monitoring would be expected to be carried out on a large installation to maintain performance.

Research and Knowledge Transfer

EPSRC Fellowship

As part of Dr. Matthew Eames' 5-year EPSRC fellowship, the Centre has been developing an early stage thermal modelling tool for buildings.



One of the key aims for the design tool is to create software that can run building simulations much more quickly without a significant loss of accuracy.

Traditional thermal models for building simulation can take hours (or even days) to run for all but the simplest buildings. Reducing the time it takes to run these simulations will provide building designers with rapid feedback and enable them to evaluate the impact of a wide range of options in a short space of time, and at the earliest stages of the design process. The Centre has been successful in creating a model which emulates more complex simulation software and can determine the thermal response of the building to a given input from only a small number of simulation runs. Once the learning phase is completed, different states of the building can be 'emulated' in a few fractions of a second. This means that large numbers of options can be evaluated extremely efficiently.

The figure above shows the results of a simulation which looked at the effect on energy use of changing two variables, the angle (or azimuth) and the glazed area of a single façade of a building. The coloured surface is the output of the new emulator which would have taken around 4.6 days to generate with the original building simulation model. With the new emulator this took less than a second.

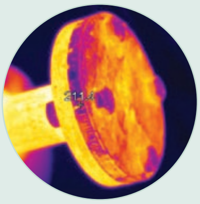
It is hoped that this simulation method can be used to optimise more complex building models, with tens or even hundreds of input variables.

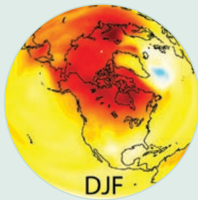
As part of the fellowship, the Centre has also been investigating the impact of hot weather on overheating in buildings. For the first time in many years the UK has experienced a period of warm weather which triggered 'level three' heatwave warnings from the Met Office for many parts of England. These warnings are triggered when the Met Office confirms that threshold temperatures have been reached for one day and the following night in one or more regions, and there is a 90% confidence that the threshold will be met on the following day. Threshold temperatures vary regionally, between 28°C and 30°C in the daytime and between 15°C and 18°C at night.

With climate change, the frequency and intensity of extreme weather events is expected to increase, and given that people spend 80% of their time indoors, there is a very real threat to public health from heat stress. Understanding the physics of overheating in buildings during extreme weather is therefore an important area of research.

Analysing mortality rates during heatwaves over the last 30 years, the Centre has uncovered flaws in the current Heat-Health Watch system which it believes could be dramatically improved. The system is designed to provide an early warning to social and healthcare services. At present, threshold values only consider maximum air temperatures, but if humidity and solar energy, which also contribute to how hot people 'feel', are considered, then more accurate warning forecasts can be made. A better understanding of the onset of heat stress, and the way that the internal environment can be managed to prevent it, will help engineers and architects design buildings which are better equipped to cope with extreme weather.

The Centre will now be looking at what this means by applying the analysis to future weather scenarios and searching for 'hot spots' that could cause localised overheating in our buildings.





UMBRELLA

Dr. Tristan Kershaw is involved in a collaborative European funded project within the Seventh Framework Programme (FP7) which will create a tool to optimise the design of a building based on stakeholder preferences using a whole life cycle approach.

Optimising energy efficiency in buildings is often a management issue and not just one of design. As such there is a need to engage a wider range of stakeholders including owners, occupiers and managers, and to consider the motivation and incentives behind traditional business models. The UMBRELLA project will develop a decision support toolset, based on a wide range of indicators which will reflect the performance of buildings in different climates across the whole of their lifecycle including:

- Design and construction of new and high performance buildings
- Retrofit solutions for existing buildings
- Operational energy use
- End of life (disposal, re-use or re-cycling of building components).

The UMBRELLA toolset will provide support for the development of innovative 'use case scenarios' which will be available through a web-based application and dynamic web portal. This will allow users to explore the different models and seek optimal solutions for individual buildings based on energy efficiency, carbon emissions, thermal comfort, running costs or embodied carbon.

Over the lifetime of a building, it is important to understand the impact of climate change on building performance and on the comfort of occupants. Design alterations or retrofit measures need to be developed with this uncertainty in mind. The Centre will play an instrumental role in modelling these outcomes, including the creation of future weather files for the whole of Europe which will be used in building simulation. This will test the validity of different 'use case scenarios' and ensure that the energy efficiency measures are compatible with expected climatic change over the life cycle of the building.

Umbrella
Business Model Innovation for High Performance Buildings Supported by Whole Life Optimisation

Key Facts

- Total budget: €2.9m
- Start date: 1st September 2012
- Project duration: 3 years
- Project coordinator: Dr. Ruth Kerrigan, Integrated Environmental Solutions Ltd.

For further information contact *T.J.Kershaw@exeter.ac.uk* or see *www.umbrella-project.eu*

List of Publications

Details of documents produced by the Centre this year are shown below.
SWEEG members can download documents from www.exeter.ac.uk/cee/sweeg

Scientist's Reports

Number	Title	Author(s)
144	*South West Devon Strategic Energy Study: The Evidence Base*	D Lash, TA Mitchell & M Wood
145	*The Development of a Method to Support Policies S7 and EN3 of the Teignbridge Local Plan 2013-2033*	D Lash, TA Mitchell & ADS Norton
146	*Establishing a Minimum Standard for New Schools in Devon*	D Lash & TA Mitchell

Internal Documents

Number	Title	Author(s)
823	*Review of Sustainability Provisions for Reserved Matters Planning Application for Eagle One Headquarters*	ADS Norton, D Lash & A Rowson
824	*Review of Sustainability Provisions for Reserved Matters Planning Application for Science Park Centre*	ADS Norton, D Lash & A Rowson
825	*Mill Water Special School Report Concerning Compliance with BB93 (Acoustics) for Building Control Submission*	M Wood
826	*Bassett's Farm School Extension Acoustic Issues Report for Compliance With BB93*	M Wood
827	*Withycombe Primary School Extension Acoustic Issues Report For Compliance With BB93*	M Wood
828	*Review of Tithebarn Green Sustainability Report*	D Lash & ADS Norton
829	*Reverberation Time of Mobile Classroom at Torre C of E School, Torquay, Devon*	M Wood
830	*King's School Extension Acoustic Issues Report For Compliance with BB93*	M Wood
831	*Exwick Heights New School Block Report Concerning Compliance with BB93 (Acoustics) for Building Control Submission*	M Wood
832	*Assessment of Plant Noise from the Paignton Sports Hub after Attenuation Measures Implemented*	TA Mitchell
833	*King's School Extension Building Control Submission for Compliance With BB93*	M Wood
834	*An update on biomass boiler performance in Cornwall, 2011-12*	TA Mitchell
835	*The Green Deal and the Non-domestic Sector*	M Wood & D Lash
836	*Sustainable City Gardens: Why Green is the Way to Go*	T Kershaw
837	*Letter Concerning the Acoustic Issues Surrounding the Installation of a Fitness Suite in the Existing Building at Westlands School*	M Wood
838	*Withycombe Primary School Extension Acoustic Report to Demonstrate Compliance with BB93*	M Wood
839	*Bassett's Farm School Extension Acoustic Report to Demonstrate Compliance with BB93*	M Wood
840	*Mill Water Special School Sports Hall Report Concerning Compliance with BB93 Acoustics for Building Control Submission*	M Wood
841	*Accessing Thermal Mass in Cornwall Council Offices*	T Kershaw
842	*Assessment of the Ambient Noise Levels Surrounding the Proposed Development Site at Rushbrook, Totnes, Devon*	M Wood
843	*Withycombe Raleigh Part L Calculations*	D Lash
844	*Rushbrook Learning Disability Hub Energy Considerations at Feasibility Stage*	D Lash

845	*The Effect of Devon's LTP3 Measures on Emissions of Carbon Dioxide*	M Wood & TA Mitchell
846	*An Analysis of the Effectiveness of Voltage Management for Reducing Energy Consumption and Carbon Emissions*	M Wood
847	*A Post Occupancy Evaluation of Bideford College*	TA Mitchell
848	*A Post Occupancy Evaluation of Montgomery Primary School*	TA Mitchell
849	*Specification for SBEM Modelling at Stage E of Mill Water School*	D Lash
850	*Sustainability Advice Regarding the Proposed Development of an Additional 600 Houses at Cranbrook*	ADS Norton
851	*Rushbrook Learning Disability Hub Design Stage C Energy Modelling*	D Lash
852	*Overheating Assessment of Knightley SSI*	T Kershaw
853	*Acoustic Compliance Assessment of a Four-Classroom Extension to Exminster Primary School*	TA Mitchell
854	*South West Exeter Urban Extension, an Initial Feasibility Assessment of Site Wide District Heating and Combined Heat and Power*	ADS Norton
855	*The Viability of Site Wide District Heating and Combined Heat and Power for Large Scale Developments in Teignbridge*	ADS Norton
856	*Installing PV across the University of Exeter estate: The Regulatory and Financial Implications*	D Lash
857	*Acoustic Assessment of Proposed Community Hub, Totnes*	TA Mitchell
858	*Early Thermal Modelling of Classroom Extension to Sidmouth College*	D Lash
859	*Early Thermal Modelling of New Block at Ladysmith Infant School*	D Lash
860	*Acoustic Compliance Assessment of an Extension to Bradley Barton Primary School*	TA Mitchell
861	*Modelling of Mill Water School to Check for Overheating*	D Lash
862	*Results from an Extended Noise Survey at the Rushbrook Community Hub site, Totnes*	TA Mitchell
863	*Early Thermal Modelling of New Sports Hall at Peter Marland School*	D Lash
864	*Stage D Modelling of New Block at Bradley Barton Primary School*	D Lash
865	*Design Stage Part L Modelling of Rushbrook*	D Lash
866	*Acoustic Assessment of a Proposed Classroom Extension to St. Mary's C of E Primary School, Bideford*	TA Mitchell
867	*Thermal Modelling of the Rushbrook Centre at the Design Stage to Test for Overheating*	D Lash

Journal Publications

Title	Journal	Author
Urban form and function as building performance parameters	Building and Environment 62(0):112-123 Apr 2013	JA Futcher, T Kershaw, G Mills
Investigating the Productivity of Office Workers to Quantify the Effectiveness of Climate Change Adaptation Measures	Building and Environment 69(0):35-43 Nov 2013	T Kershaw, D Lash
Lumped parameter models for building thermal modelling: An analytic approach to simplifying complex multi-layered constructions	Energy and Buildings, volume 60, pages 174-184 (2013).	AP. Ramallo-Gonzalez, M.E. Eames, DA Coley
Limitations of the CIBSE Design Summer Year (DSY) approach for delivering representative near-extreme summer weather conditions	Building Services Engineering Research and Technology doi:10.1177 /0143624413478436.	MF Jentsch, GJ Levermore, JB Parkinson and ME Eames

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