Shaping Agendas in HE

The impact of potential changing energy, emissions and adaptation drivers through the 2020s

March 2014

AUDE Excellence in estates and facilities

ARUP

Executive summary

We are all aware of the national target for an 80% reduction in carbon emissions by 2050 but the reality of how this is likely to be achieved is less well understood. The building sector has a harder target than most as, to offset sectors where emissions reductions are harder to achieve, it is expected to be zero carbon by 2050. To achieve these targets, significant change will be needed throughout 2020s, within the forward estates strategies of many universities.

This report, funding jointly by Arup and the Association of University Directors of Estates (AUDE) is intended to highlight the risks and opportunities that should be included within estates strategies currently under development, focusing on four key areas:

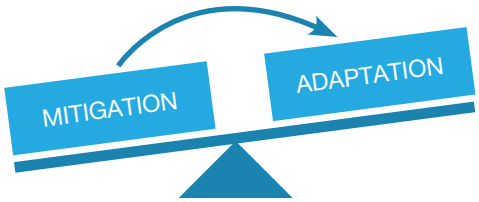
Energy efficiency & building design

- 2019 will see the introduction of Building Regulations requiring 'zero carbon'
- Renovations must also be 'nearly zero energy buildings' by 2020
- Embodied carbon is likely to be measured and regulated for
- Timber is favoured as a construction material as opposed to consuming it as an energy source
- The performance gap between predicted and actual energy consumption will become more important

Adaptation & resilience

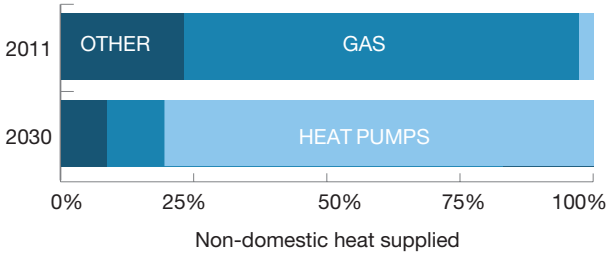
Adaptation in buildings is far behind mitigation both in understanding and legislation. This is set to change, driven by the realisation that, of all the climate risks, building overheating has one of the greatest needs for urgent action.

Adaptation and resilience should be addressed at a campus and building scale and used to de-risk future university strategies.



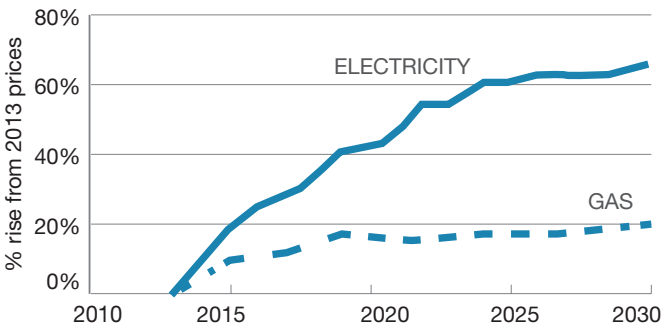
Energy supply

- Slow decarbonisation of National Grid could impact on university targets
- Self-generation using gas-fired CHP will become the high-carbon option when compared with a decarbonised National Grid
- Rise in use of heat pumps and networks



Financial incentives & burdens

- Electricity prices projected to continue rising, with Carbon Price Support for CHP>2MW also rising significantly.
- Feed-in Tariffs and non-domestic Renewable Heat Incentive worth investigating.
- Be aware of impact of minimum EPC in 2018.



1 Introduction

‘Green’ issues are widely discussed in all disciplines of popular and specialist media. The frequently quoted ultimate goal for the UK is the 80% reduction in carbon emissions in 2050.[1]

Less well publicised are the details of the ways that the targets are likely to be met. These scenarios will inform government thinking in the years and decades to come. 2050 seems far into the future but many of the pathways to the required changes need to start before the end of the current decade and the 2020’s are vital, with the technological and behavioural shifts in this decade laying the groundwork for future progress towards the target.

The 2020’s may not be of concern to short-term focussed sectors such as speculative office development but it is within the timescales often considered within the higher education (HE) sector. Many universities have an estates strategy stretching 10 - 15 years into the future and it is our experience that very few fully consider the potential changes to external drivers in that time.

As such, this report, funded jointly by Arup and the Sustainability Advisory Group of AUDE, is intended to highlight the risks and opportunities that should be included within estates strategies currently under development.

How does the estates development challenge need to respond now to plan for potential regulatory changes in the medium term?

In terms of carbon, energy and wider sustainability, many of the easy decisions have already been taken. Now is the time to integrate the estates strategy and the carbon agenda into the wider institution context as this impending rapid change in estates practices is not happening in isolation.

The HE sector is going through great change, coming to terms with shifts in funding priorities away from government grants to student fees and research income, changes to student demographics and future uncertainty over pedagogy change and the influence of MOOCs (Massive Open Online Courses).

Meanwhile, the voice of students, both current and prospective, is becoming clearer – sustainability is important.[2]

The intention of this work is to aide capacity building within institutions to de-risk the estates development challenge within the next 15 years and to clarify the opportunities that might exist.

In the last year alone, 25 reports have been released by government departments or by bodies advising on policy direction, leading to a seemingly confusing and ever-changing regulatory landscape.

We have drawn some of the more important issues from these publications relating to the following topics:

1. Energy efficiency & building design

2. Energy supply

3. Adaptation and resilience

4. Financial burdens and opportunities

We hope they serve to stimulate discussion and raise the profile of future challenges.

2 Energy Efficiency and Building design

New buildings – regulations

Whilst the industry is examining the impact of the recent amendments to building regulations, the future holds still greater change.

The recast European Performance of Buildings Directive[3] (EPBD) states that:

> by 2020, all new buildings and existing buildings undergoing major renovation must be nearly zero energy buildings.

The government's expected response to this is that the planned 2019 update to building regulations will mark the introduction of mandatory 'zero carbon' non-domestic buildings. Whilst the exact definition of this is not yet set, it is likely to require significant progress from the current position (estimated by the UK-Green Building Council (UK-GBC) as being a 35-40% reduction compared with 2010 regulations).[4] This has potential implications for build costs, programs and procurement routes.

The sector has recently made progress on increasing the efficiency of its estate. In some areas this enthusiasm is waning as the easy wins have been taken, costs are increasing and the pressure from funding bodies has reduced.

The changes ahead are likely to require a greater transformation than this previous progress and will be mandatory. Of the institutions who provided input into this report, the majority were not planning for this issue.

Existing buildings

Many estates strategies currently are focussed on improving their existing building stock, for which the inclusion of major renovations within the EPBD potentially provides greater concern.

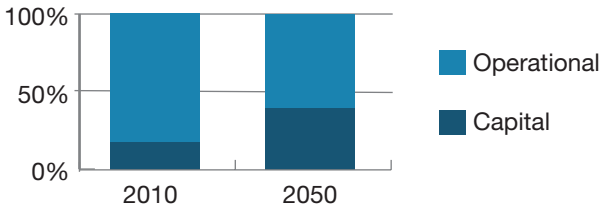
The mind-shift that will be needed to create near-zero-energy major renovations needs to be reinforced in all refurbishment projects. The sector is not likely to have the luxury of cherry-picking the most financially attractive carbon reduction options. The 4th Carbon Budget assumes that all cost effective and practical measures are implemented.[1]

The Green Construction Board (GCB) [5] goes further, saying that, eventually, the uptake of all technically viable solutions will be required including those that at present do not have a financial return on investment over their lifetime. To implement this would need significant interventions from government in the form of incentives and penalties.

The effect of the required changes relating to existing buildings may reach the HE sector quicker than others due to the occasionally short refurbishment cycles of buildings driven by research programs.

Embodied (capital) carbon

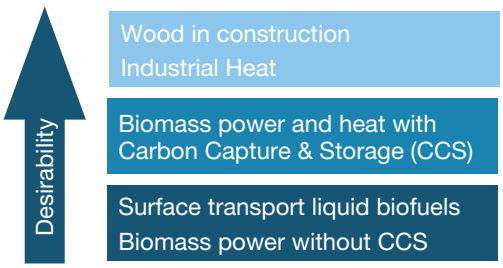
In 2010, embodied carbon accounted for 18% of the emissions from the built environment. Even with reductions, this proportion is expected to rise to around 40% in 2050 and, given that the entire sector is expected to be zero carbon[1] it cannot go unregulated, simply relying on other factors such as electricity grid decarbonisation to drive reductions.



The GCB recommends the mandatory measuring and reporting of whole-life carbon (including embodied) for all buildings by 2022 [7] whereas the UK-GBC proposes it being included in the definition for zero carbon from 2025[4]. However, both bodies recognise there is a need for standards relating to carbon measurement to be developed before this can happen.

Wood – burn it or build with it?

Timber used in construction has the potential to contribute to the required embodied carbon reductions. However, recent uses for biofuels are not what the Committee on Climate Change (CCC – the statutory body advising the government) considers to be the most desirable uses in 2050: [8]



These alternatives might encourage and benefit from a move to off-site modular construction which also aides a separate area of focus, that of reducing waste from construction.

Performance gap

Currently, the regulations aimed at reducing buildings' emissions only address around half of the total emissions. In addition, the calculations used during the design process are intended to prove compliance rather than accurately predict the energy consumption in use.

Therefore, it is possible for the 'performance gap' between predicted and real-world situations to be responsible for the doubling or tripling of energy and emissions levels. This is at odds with efforts to realise drastic emissions reductions.

Within the HE sector, the usage patterns and equipment intensities of university buildings are even more variable and difficult to predict compared with more standard uses such as retail or offices.

This potentially increases the risk to the sector that regulations and the calculations that support them might not be suitable. Perhaps in the short-term, more common use of CIBSE's TM54 [9] methodology would promote increased understanding.

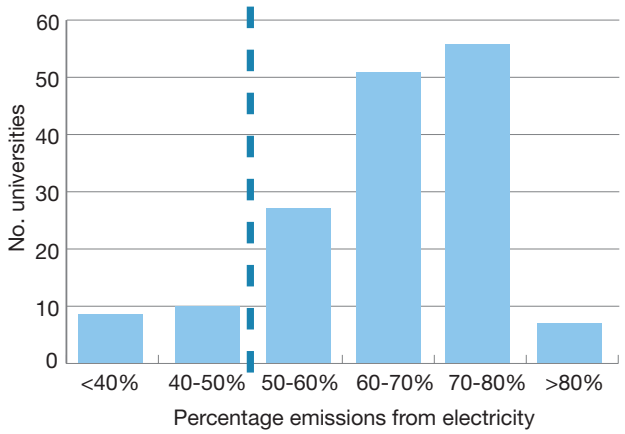
Coupled with an increased use of 'Soft Landings' [10] and the establishment of feedback cycles to designers and clients alike, this would significantly increase the understanding of this issue across the sector.

The direction of the industry in this field is indicated by the fact that 'Government Soft Landings' is to be mandatory on all central government projects in 2016.

3 Energy Supply

A low carbon National Grid?

For the vast majority of universities, emissions from electricity outweigh those from heating fuels: [11]



During the 2020's, as a result of a switch from coal to renewables and nuclear, the carbon intensity of the National Grid is expected to decrease significantly from the current figure of around 500g/kWh to less than 50g/kWh in 2030.

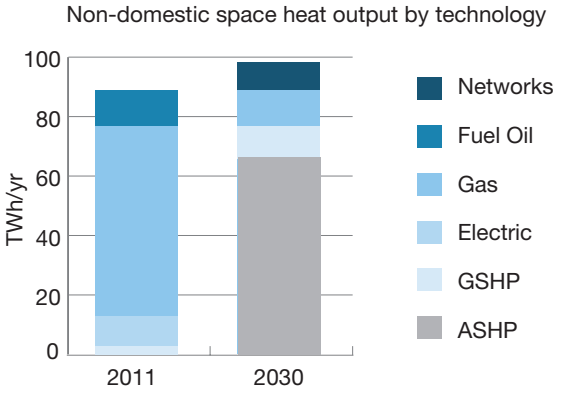
Across the construction sector, this change is expected to deliver about half of the required emissions reductions by 2050 [5] and, understandably, many universities are relying on this to meet their targets.

However, certain recent scenarios to 2050 have the figure only reaching 100g/kWh and there is a general lack of confidence in the government's strength of ambition for decarbonisation [12]. This has been exacerbated by the refusal to set a concrete target on the issue.

For those that have included this aspect in their carbon management plans, a sensitivity analysis is advisable to examine the scale of the impact not just at 2050 but at intermediate targets such as 2020 when the reduction is still significant to a level of around 300g/kWh.

Heat pumps

There are many projections for how we will be heating our non-domestic buildings in 2030. Not all of them agree on the exact figures but the message is clear – heat pumps are seen as the future of heating, with ground source (GSHP) and air-source (ASHP) variants contributing around a combined 80% of energy in 2030 from just 3% at the moment. [13]



Whether this is feasible or not is for debate. With an average replacement cycle for heating systems in non-domestic buildings of around 25 years, action is going to be needed in the very short term to switch current and imminent projects away from the current default of gas boilers.

This potential wholesale change to heat pumps could have various impacts which should be considered in estates strategies focusing on the next ten years.

If a new building or retrofit is designed in the next decade or so with gas boilers the chances are that, when they need replacing, it will be with an air source heat pump. Space on the roof or elsewhere will be needed for heat exchangers and the electrical infrastructure will need to be able to cope with an increased level of demand. In addition, heat pumps often work on lower temperatures so the heat delivery system (e.g. radiators) may need alteration.

Spending a few moments to build in flexibility and adaptability surrounding these and other potential issues during the design phase may avoid building in insurmountable barriers to be addressed at a later date.

Heat networks

Whilst not as drastic as the change in fortunes for heat pumps, heat networks are projected to supply 7% of non-domestic heat by 2030. The proportion of energy supplied by heat networks within universities could be expected to be even higher given that some of the main barriers to development are lessened in the sector.

Heat networks that are connections of a number of relatively small capacity heat sources are likely to be more suitable for easy expansion rather than those with single large energy centres. A provision for future additional plant room space could be considered during current designs (even if that space is utilised initially for other uses). Systems such as these would also provide increased resilience.

> In the 2020s, gas CHP will be the high-carbon option but will still have a vital role in heat networks.

Many heat networks that are currently being developed are based around gas fired CHP, the emissions savings for which are compared with an ever-improving National Grid. At the point when the carbon intensity of the National Grid reaches 300g/kWh, gas CHP begins to be more carbon intensive than standard boilers and supplied electricity. This threshold is expected to be passed in 2021 and even if reality lags behind the projections, the cross-over point is likely to be early in the lifetime of systems being proposed and designed now.

To combat this, biomass, anaerobic digestion and large heat pumps are expected to be important heat sources for heat networks through the 2020's although gas-CHP continues to be important as heat networks have benefits other than simple like-for-like carbon comparisons. [14]

A new ownership model?

In its recent strategy on community energy [15], the government recognises the social, economic and environmental benefits of community-led action on generating energy that go far beyond simply producing low-carbon energy.

In this strategy, the role of partnerships with local organisations is seen as a key factor in increasing the reach and scale of community energy in the UK. In urban areas, this could potentially include neighbouring institutions.

Engaging with wider communities in this way could lead to increased opportunities for some universities to be involved in developing energy generation schemes whilst contributing to other corporate social responsibility efforts.

Future technologies

Predicting the future commercialisation of technologies in particular sectors is challenging. However, the recent update to the UK Renewable Energy Roadmap [16] highlights energy from waste and anaerobic digestion as key recipients of development funding over the coming years.

4 Adaptation and resilience

Mitigation
Protecting the climate from society

Adaptation
Protecting society from the climate

Climate change mitigation (reducing emissions to try to slow climate change) is well understood and quantifiable. By contrast, climate change adaptation (adapting buildings and behaviours to cope with the climate change that is increasingly considered inevitable) is a poor relation.

Whilst reductions in heating bills are seen as an opportunity, the risks are significant.

> Of all climate risks, the overheating of buildings has one of the greatest needs for action in the next five years. [17]

Other risks to the sector's estate include flooding (and associated insurance costs), water scarcity and the increasing prevalence and scale of the 'Urban Heat Island' effect. [18]

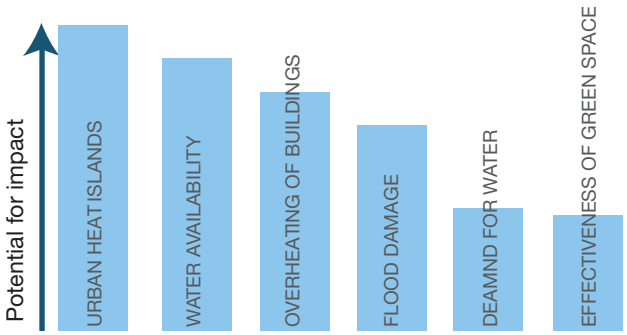
For new buildings, there is the potential to reduce overheating risk through exposed thermal mass, increased air tightness, optimising form and orientation, the use of effective summer shading and appropriate glazing ratios.

These actions are possible to incorporate on new buildings. However, existing assets such as heritage buildings are often good performers in terms of overheating due to accessible thermal mass, high ceilings and sensible glazing ratios.

They often lend themselves well to the fitment of highly effective ceiling fans, an often overlooked measure due to the fact that current dynamic simulation modelling software relied on to predict overheating rates cannot take their benefits into account.

No one single answer

One assessment [18] of the importance of various adaptation factors to the built environment is shown below. Every institutions' response to these factors will vary but it is likely that none will be unaffected.



The key is to begin to develop comprehensive risk assessments, evaluating the potential impact of each of the factors.

A response to policy or good business sense?

A policy response to adaptation has begun in the form of the adaptation reporting power which requires certain organisations to provide proof of their analysis of the impacts and their approach to the risk they pose.

Universities are not included within the second round of invitations to report although the structure of the policy could give an indication of the future direction and the characteristics used to identify reporting organisations[19] mean that the sector seems more likely to be asked to report in the future than private sector businesses.

However, it seems that mandatory reporting in the short term is unlikely. Therefore it falls to the sector to realise that adaptation planning makes good business sense. It should not be seen as a sustainability issue but as a business-risk issue.

> Of all the sustainability issues, adaptation is the least well understood and the one which potentially poses the greatest risk.

Resilience beyond adaptation

Discussions of adaptation quickly conjure up images of eliminating risks by 'fixing' assets such as buildings or stormwater management systems. These conversations focus on events which might happen, such as heatwaves, flooding or extreme weather and don't encourage action.

A more useful discussion needs to happen around resilience which goes further than adaptation to explore not only what the potential impacts might be but how well the university could recover.

Discussing resilience as opposed to adaptation increases the relevance of the issue by reframing the question as:

> When an abstract risk linked to climate change turns into a real event with real impacts, how will the university cope?

This extends the thinking into the realm of operational procedures and has the potential to better identify risks to resilience along with the critical interdependencies between systems.

Gradual adaptation

One of the biggest barriers against adaptation being incorporated into estates strategies is one of timescales. Whilst mitigation is seen as a problem for the present, adaptation is an issue for the future. This should not be the case.

Buildings and other campus-wide infrastructure designed now is expected to last 20-25 years before a major refurbishment, by which time weather patterns are predicted to have altered significantly.

We don't need to construct buildings, storm-water systems and green spaces (amongst others) that can cope now with the conditions they will experience at the end of their life, we need a plan to gradually adapt a building or campus within the natural refurbishment and replacement cycles. [20]

> Every project that doesn't consider adaptation is a lost opportunity that locks in a commitment to future costs.

5 Financial burdens and incentives

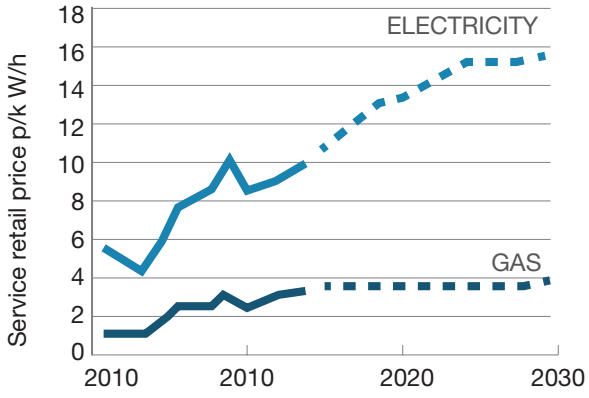
It can seem as though the initiatives aimed at incentivising or penalising various aspects of energy consumption and generation are ever-changing and, in general, confusing. Calls for transparency and long-term consistency are coming from many in the industry.

Bodies such as the UK-Green Building Council recognise that energy costs alone are not sufficient to promote action. In their Fifth Progress Report, the Committee on Climate Change commented on the need to strengthen incentives whilst also rationalising the multiplicity of policies. [21]

Therefore, we can realistically expect incentives or penalties aimed at encouraging movement in the directions mentioned in the previous sections to appear in due course.

Energy price projections

Energy prices have effectively doubled in the last decade and the trend is predicted to continue, with increases of nearly 45% expected in electricity prices by 2020. [22]

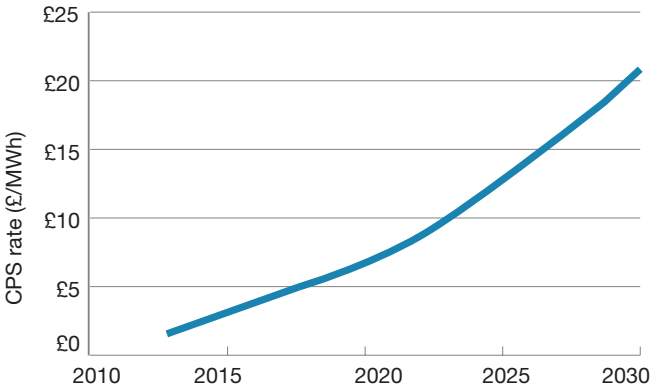


These projections should be used to determine the financial viability of schemes currently being examined to reduce energy consumption.

Carbon price support

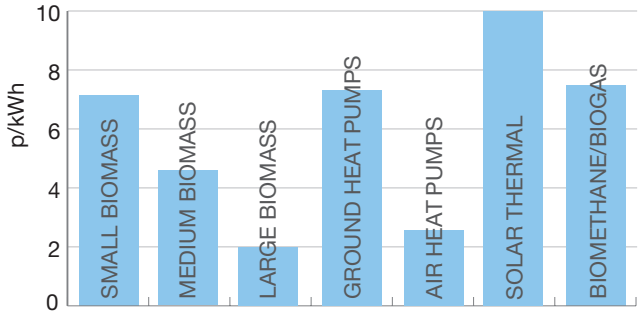
In April 2013, the government introduced a new tax on fossil fuels used to generate electricity called the Climate Change Levy Carbon Price Support (CPS), applicable to operators of CHP plant over 2MWe. From 1st April 2014, 0.175p/kWh is chargeable on the proportion of gas used for the electricity component.

Whilst this may not sound like much, the charge is expected to increase significantly to create a 'carbon price floor' of £70/tCO_2 as shown nominally below. [23]



Non-domestic RHI

The Renewable Heat Incentive (RHI) has been running in the non-domestic sector for a number of years, providing payments for the 20 year life of the installation, reflecting a 12% internal rate of return. [24]



New technologies are being added to the scheme from April 2014 including medium and large biogas, CHP, deep geothermal and air-to-water heat pumps. [25]

Feed-in tariffs

Under the Feed-in Tariff (FiT) scheme, those generating electricity using one of the permitted technologies are paid for each unit of energy (kWh) they produce. These payments are in addition to any savings resulting from reduced energy bills and payments received for 'selling' electricity to the National Grid.

The tariffs involved drastically affect the financial viability of the technologies and the scheme is expected to be open to new applications for some time.

Whilst the structure of the scheme has remained relatively constant, the frequent changes to the rates mean that re-evaluation is required for each project.

Minimum EPC standards

As a result of the Energy Act, from 2018, a minimum energy efficiency standard will apply to rented buildings. Whilst the level of the standard has not been officially set, it is expected that buildings with an Energy Performance Certificate rating less than an 'E' will need to be improved before they can be re-let.

Whilst most universities own the majority of their academic buildings, this regulation could cause issues around student residences.

Energy savings opportunity scheme

In 2014, the Energy Savings Opportunity Scheme (ESOS) is due to be launched. It is aimed at reducing energy demand and will require all large enterprises to undertake an energy audit by 2015 and every four years thereafter.

Whether all universities will be included in the requirements is not clear from the consultation paper. The definition used is that if a university is 'financed for the most part' by a public body then it does not need to comply. Therefore a university's finance arrangements will determine whether it needs to undertake an assessment. [26]

The cost of the first assessment is estimated at around £17,000 not including the cost of implementing any recommendations.

Allowable solutions

When the zero carbon standard for new housing is introduced in 2016, the regulations will set a maximum carbon emissions level to be delivered using 'on-site' technologies. The remaining emissions will be able to be offset through allowable solutions – effectively paying someone else to reduce their emissions instead of reducing a new home's emissions to zero.

This could provide a source of funding of the order of £225m nationally. The details are not set but the government's consultation paper [27] suggests that there may be ways for universities to access these funds.

6 About us

Arup

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. We offer a broad range of professional services that combine to make a real difference to our clients and the communities in which we work.

We are truly global. From 90 offices in 35 countries, our 10,000 planners, designers, engineers and consultants deliver innovative projects across the world with creativity and passion.

Founded in 1946 with an enduring set of values, our unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working.

This is reflected in everything we do, allowing us to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of our clients.

AUDE

AUDE is a representative organisation working on behalf of members to harness the collective expertise of the sector in addressing common issues.

AUDE provides guidance, training and networking opportunities, maintains extensive contacts and ensures the views of Estates / FM professionals are heard in all appropriate arenas.

AUDE promotes excellence in the strategic planning management, operation and development of Higher Education Estates and Facilities

Readers should appreciate that this is a very high-level look at the issues. In order to keep it short and interesting, some generalities and assumptions have had to be made that may not represent all situations within the sector.

Recent reports of interest

The following reports are those of interest which have been reviewed in the course of this work, many released in the past year, and which indicate the government's future direction.

Title	Date	Relevant aspects
Committee on Climate Change (CCC)		
How well is the UK prepared for climate change (Adaptation Sub-Committee)	Sept 2010	Chapter on 'what should be happening today to prepare for climate change' includes designing and renovating buildings as a key focus.
The Fourth Carbon Budget- Reducing emissions through the 2020's	Dec 2010	Actions and strategies for the 2020's that will enable the 2050 targets to be met. Includes actions for the built environment and power sector decarbonisation.
Bioenergy review	Dec 2011	Includes comparison of priorities for use of finite land space for crops and for use of bio-fuels produced.
Reducing the UK's carbon footprint	Apr 2013	An examination of the consumption-based (~Scope 3) emissions for the UK, including confirmation that Low-carbon technologies provide emissions savings even when a whole-life approach is taken.
Next steps on Electricity Markey Reform- securing the benefits of low-carbon investment	May 2013	Sets out a plan through the 2020s for the decarbonisation of the National Grid by 2030 but introduces the potential relaxing of the 2030 target.
Meeting Carbon Budgets- 2013 Progress Report to Parliament	Jun 2013	States that the UK is not on track to meet the third and fourth carbon budgets, requiring n imminent and significant increase in the pace of emissions reductions
Fourth Carbon Budget Review: Part 1	Nov 2013	A review of climate science and the national and international situation that concludes there is no need to alter the 2050 targets in legislation.
Fourth Carbon Budget Review: Part 2	Dec 2013	An appraisal of the most cost-effective pathway to the 2050 target, including the conclusion that acting in the 2020s is more cost effective than delaying actions until the 2030s
Office for Low Emission Vehicles		
Driving the Future Today: A strategy for the ultra-low emission vehicles	Sept 2013	Includes the vision for transport in the UK along with the potential impacts for infrastructure and buildings.
UK Green Building Council (UK-GBC)		
Building Zero Carbon- the case for action	Feb 2014	Sets out the position of the industry in relation to reducing the building emissions allowed by Building Regulations. Calls for strong targets with

Title	Date	Relevant aspects
Department of Energy & Climate Change (DECC)		
UK Renewable Energy Roadmap	Jul 2011	Sets out the key actions related to each of eight key technologies for the UK to progress towards its 2020 targets
The Future of Heating: A strategic framework for low carbon heat in the UK	Mar 2012	Consultation paper setting out the government's preferred approach including managing heat demand in buildings and heat network supply options.
UK Bioenergy Strategy	Apr 2012	Sets out the framework of principles for the UK's bioenergy policy and indicates future policy direction.
The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK	Nov 2012	Sets out the commitment to energy efficiency, the barriers and the opportunities.
The Future of Heating: Meeting the challenge	Mar 2013	Sets out a Heat Strategy Timeline for reducing demand and moving to a low carbon heat supply including heat networks and single-building solutions
Energy Savings Opportunity Scheme (ESOS)	Jul 2013	Consultation paper which indicates the government's preferred options for mandatory energy audits in some sectors.
Updated Energy and Emissions Projections 2013	Sept 2013	Expected projections for carbon and energy issues through the 2020s including energy prices.
UK Solar PV Strategy Part : Roadmap to a Brighter Future	Oct 2013	Includes long-term commitment to the importance of photovoltaics to the UK's carbon targets.
UK Renewable Energy Roadmap Update 2013	Nov 2013	Summarises progress towards renewable energy targets and sets out future direction for various technologies.
Energy Efficiency Strategy: 2013 update	Dec 2013	Summarises progress towards the Energy Efficiency Strategy and provides a route map for the coming years in terms of ESOS, Energy Demand Reduction programs, smart meters and the Green Investment Bank.
Non-Domestic Renewable Heat Incentive: Improving Support, Increasing Intake	Dec 2013	Includes a summary of policy decisions to have imminent effect and longer term implementation timelines for a number of aspects.
Community Energy Strategy Full Report	Jan 2014	Recognises the changes in the way energy is being produced in the UK and the benefits of including communities in energy policies and encouraging partnerships.
HM Government		
The Carbon Plan: Delivering our low carbon future	Dec 2011	Sets out the government's plan for the next decade and the 2020s in terms of low carbon buildings, transport, industry and electricity.
Adapting to Climate Change: Ensuring Progress in Key Sectors	Jul 2013	Strategy for exercising the Adaptation Reporting Power and list of priority reporting authorities
Construction 2025 – Industrial Strategy; government and industry in partnership	Jul 2013	Sets out the importance of the construction industry to the UK and a strategy for maximising impact including a smart industry focussing on sustainability.
The National Adaptation Programme Making the country resilient to a changing climate	Jul 2013	Sets out the main risks and focus areas to increase resilience to climate change in a number of sectors including the built environment and infrastructure.
Department for the Environment and Rural Affairs (DEFRA)		
Climate Change Risk Assessment for the Built Environment Sector (by external consultants)	Jan 2012	Details the key risks and potential impacts of climate change on the built environment
The Green Construction Board		
Low Carbon Route-map for the UK Built Environment	Mar 2013	Defines scenarios for the built environment sector to achieve an 80% reduction in emissions by 2050 including operational and capital carbon.

Specific references

1. Committee on Climate Change, Fourth Carbon Budget – Reducing Emissions through the 2020's, Dec 2010

2. The Higher Education Academy, Student attitudes towards and skills for sustainable development, Sept 2013

3. Directive 2010/31/EU of the European Parliament and of the Council'

4. The UK Green Building Council, Building Zero Carbon – the case for action, Feb 2014

5. The Green Construction Board, Low Carbon Routemap for the UK Built Environment - Report, Mar 2013

7. The Green Construction Board, Low Carbon Routemap for the UK Built Environment – Visual Guide, March 2013

8. Committee on Climate Change, Bioenergy Review, December 2011

9. Chartered Institute of Building Services Engineers, TM54: Evaluating operational energy performance of buildings at the design stage, August 2013

10. Soft Landings is a framework for action developed by BSRIA intended to provide a staged hand-over from design and construction teams to clients with the intention of providing a building that is performing better whilst also allowing the design teams to learn from the real-world performance of the building. 'Government Soft Landings' is a version of the framework to be applied to government buildings.

11. Analysis of HESA Statistics 2011/12

12 Committee on Climate Change, Next steps on Electricity Market Reform – securing the benefits of low-carbon investment, May 2013

13. DECC, The Future of Heating: Meeting the Challenge – Evidence Annex, March 2013 [figures approximately taken from Chart A2]

14. DECC, The Future of Heating: Meeting the Challenge, March 2013

15. DECC, Community Energy Strategy: Full Report , Jan 2014

16. DECC, UK Renewable Energy Roadmap Update 2013, Nov 2013

17. DEFRA, The UK Climate Change Risk Assessment 2012 Evidence report, ,January 2012 [Box ES3]

18. "During the heat wave events across South East England in August 2003 and July 2006 night-time air temperatures in London were 6–9°C higher than those recorded for rural locations south of London (Mayor of London, 2006). Such effects have been observed in urban centres elsewhere in the UK e.g. Birmingham and Manchester" DEFRA, Climate Change Risk Assessment for the Built Environment Sector, January 2012

19. The government has applied the following six characteristics as guidance (some abbreviated):

• The extent to which in carrying out the function in question the body is publicly funded

• The extent to which the organisation's activities are underpinned by statute.

• Whether the organisation exercises extensive or monopolistic powers

• Whether the organisation's source of power is derived from more than voluntary submission to its jurisdiction.

• whether the organisation seeks to achieve some collective benefit for the public, and is accepted by the public as having the authority to do so

• In the case of a regulatory organisation, whether but for the existence of that organisation, the government would inevitably have intervened to regulate the activity in question"

DEFRA, Adapting to Climate Change: Ensuring Progress in Key Sectors 2013 Strategy for exercising the Adaptation Reporting Power and list of priority reporting authorities, Jul 2013

20. For further explanation on the concept of 'gradual adaptation', see the Technology Strategy Board's 'Design for a Future Climate' competition, particularly the project on Church View in Doncaster carried out by Bauman Lyons Architects and Arup. Other examples of adaptation exist in the implementation of mitigating technologies such as solar control glass or techniques such as passive design for effective natural ventilation.

However, case studies of wholesale adaptation are difficult to find as adaptation in any one circumstance only responds to a project-specific subset of adaptation risks so the results manifest themselves as responses to individual risks such as flooding or overheating rather than an all-encompassing 'well-adapted' building.

In addition, adaptation is often a project process that subtly changes the way a building (or other infrastructure) is designed making the identification of overtly obvious adaptation features difficult.

21. Committee on Climate Change, Meeting Carbon Budgets – 2013 Progress Report to Parliament, Jun 2013

22. DECC, Updated Energy & Emissions Projections – September 2013: Annex F Fossil fuel, wholesale and retail prices

23. Based on DECC estimates for EU Allowance (EUA) prices and total carbon price including CPS with annual inflation of 3% assumed

24. https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi/tariffs-and-payments

25. DECC, Non-Domestic Renewable Heat Incentive: Improving Support, Increasing Uptake, Dec 2013

26. DECC, Energy Savings Opportunity Scheme (ESOS) Consultation, Jul 2013

27. Based on average payment of £1500 per house (using the central price cap option) and 150,000 homes per year

Department for Communities and Local Government, Next Steps to Zero Carbon Homes – Allowable Solutions, Aug 2013

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