Principles of conservation and sustainability are easily married but often at odds for architects under increasing pressure to address the energy needs of older buildings. By incorporating UK and international case studies with more theoretical essays, this book seeks to identify overlaps in the interests of energy and building conservation.

The varied expertise of the contributors – architects, surveyors, consultants and academics – demonstrates the use of qualitative and quantitative frames of reference. The second part of the book showcases sustainable domestic and non-domestic heritage projects, translating the challenges of the preceding research into varied methods that practitioners can use to question and review their everyday work.

The book will appeal to all architects, building professionals and designers working with traditional buildings and will enhance readers' ambitions, so that they feel equipped and inspired to work with old buildings sensitively, creatively and sustainably.

DR ORIEL PRIZEMAN is a RIBA Accredited Conservation Architect trained at Cambridge and the Architectural Association. She ran her own practice focusing on work to listed houses in the Cambridge area from 1996–2012 and established a new MSc in Sustainable Building Conservation at the Welsh School of Architecture, Cardiff University in September 2013.

“This book illustrates the dilemma between ‘do nothing’ and ‘do everything possible’, with telling lessons in how great architecture from the past was designed to work with rather than fight the environment, and how well-informed sensitivity can both protect and enhance our most precious built heritage.”

ROBERT FRANKLIN, RIBA SCA

“A compendium of top notch theoretical and practical expertise on the inherent sustainability of existing buildings, and an ideal companion to British Standard 7913 on historic building conservation. This is an impressive and important rallying call for architects to take pride in their role as guardians of our built heritage.”

DR SEAN O'REILLY, DIRECTOR, THE INSTITUTE OF HISTORIC BUILDING CONSERVATION (IHBC)
## Contents

Preface and acknowledgements iv  
Contributors v  
Introduction  Oriel Prizeman ix  

### Part 1: Evaluations – Theories  

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Author(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>The English climate and enduring principles of environmental design</td>
<td>Dean Hawkes</td>
<td>3</td>
</tr>
<tr>
<td>Two</td>
<td>The energy context of domestic traditional buildings for the UK</td>
<td>Simon Lannon, Heledd Iorwerth, Xiaojun Li and Diana Waldron</td>
<td>39</td>
</tr>
<tr>
<td>Three</td>
<td>Retrofitting heritage buildings</td>
<td>Peter Cox</td>
<td>65</td>
</tr>
<tr>
<td>Four</td>
<td>Containing the questions</td>
<td>Douglas D Kent</td>
<td>87</td>
</tr>
</tbody>
</table>

### Part 2: Responses – Practices  

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Author(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five</td>
<td>An integrated approach to heritage and sustainability: four academic building projects in the US</td>
<td>Tom Hotaling</td>
<td>115</td>
</tr>
<tr>
<td>Six</td>
<td>New Court, Trinity College, Cambridge: continuing a legacy of inhabitation</td>
<td>Oliver Smith</td>
<td>159</td>
</tr>
<tr>
<td>Seven</td>
<td>Four case studies demonstrating the impacts of energy conservation in traditional domestic buildings</td>
<td>Oriel Prizeman</td>
<td>193</td>
</tr>
<tr>
<td>Eight</td>
<td>Sustaining heating in places of worship: Physical, social, organisational and commercial factors as determinants of strategic decision-making and practical outcomes</td>
<td>Bruce Induni</td>
<td>219</td>
</tr>
</tbody>
</table>

### Part 3: Conclusions  

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Glossary</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
<td>257</td>
</tr>
<tr>
<td></td>
<td>Image credits</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>Index</td>
<td>267</td>
</tr>
</tbody>
</table>
Contributors

PETER COX

Peter Cox is president of the ICOMOS (International Council on Monuments and Sites) International Scientific Committee for Energy and Sustainability. He is the founding member of Carrig and brings over 30 years of stone conservation experience in historical buildings and all types of porous building materials. Peter is responsible for the company development and has brought many exciting projects to be worked on by the team. Peter remains involved in all projects which are handled by the Carrig team.

From 1985 to 1994, he operated as European Marketing Director for ProSoCo Inc and its subsidiary MNSC, which specialised in laboratory analysis of prescribed cleaning and treatment systems for all porous building materials. While in the United States, he was involved in projects such as Grand Central Station, New York, and the US Capitol Building in Washington, DC, and in the UK he worked with prestigious buildings such as Lloyd's Register of Shipping, London, Tate Gallery of Modern Art, Bankside Power Station and Fort Dunlop.

Peter is currently vice-president of ICOMOS Ireland, having been President from 2004 to 2006. Peter has played a big role in the Stone Federation of Great Britain, chairing the technical committee, and served as vice chair of the approved contractors' scheme. While working in the USA, he was an active member of the Association of Preservation Technology (APT). He has served on the committee researching chemical consolidation methods for decay and is an associate of the International Institute of Conservation.
TOM HOTALING

Tom Hotaling is a principal and designer with Ann Beha Architects (ABA), a Boston-based design firm whose work is marked by its strong historic and cultural content. ABA's work ranges from renovations and adaptive reuse combining preservation with contemporary design, to new buildings in historic settings. The firm is currently designing renovations to the campus of the United States Embassy in Athens, whose landmarked Chancery building was designed by Walter Gropius in 1961.

In the greater Boston area his cultural and academic clients include Old North Church, the Museum of Fine Arts, the Massachusetts Institute of Technology, the New England Conservatory of Music, and Louis Kahn's Library at Phillips Exeter Academy. Nationally, his clients have included the University of Pennsylvania, Washington University in St Louis, the Arizona State Museum, and the Portland Art Museum in Oregon.

He has served as a grants reviewer for the Pew Charitable Trust and teaches a course in preservation and adaptive reuse at Harvard University. He is a Commissioner for the Boston Landmarks Commission and a trustee for the Instituto Internacional, an educational and cultural centre in Madrid whose building is a Spanish national landmark.

DEAN HAWKES

Dean Hawkes is emeritus professor of architectural design at the Welsh School of Architecture, Cardiff University, and an emeritus fellow of Darwin College, University of Cambridge. He taught and researched at Cambridge from 1965 to 1995, when he was appointed professor of architectural design at Cardiff. Following his retirement in 2002 he returned to Cambridge as a fellow of Darwin College.

Dean has held visiting professorships at schools of architecture in Hong Kong, Singapore, Glasgow, Huddersfield and Leicester. His research is in the field of environmental design in architecture. His books include The Environmental Tradition (1996), The Environmental Imagination (2008) and Architecture and Climate (2012). His buildings, in partnership with Stephen Greenberg, have received four RIBA Architecture Awards. In 2010 he received the RIBA Annie Spink Award in recognition of his contribution to architectural education.

BRUCE INDUNI

Dr Bruce Induni, born of a line of Italian marble carvers, trained in stone conservation at Wells Cathedral. After accumulating 13 years' experience as a conservation contractor, Bruce moved into academia as a senior lecturer in building conservation. His doctorate examined the survival
of medieval plaster in Dorset churches. This built on and extended a particular interest in how
the heat and humidity inside ancient buildings impacts on mortar, masonry and decoration.

He is currently teaching at Kingston and Plymouth Universities and the Building Crafts
College, and has just written the course material for a major educational initiative jointly
sponsored by the North of England Civic Trust and English Heritage.

Future plans include the completion of a handbook of applied conservation and an
independent review of the methods of ruin conservation adopted by the Ministry of Works.

DOUGLAS KENT

Douglas Kent is a chartered building surveyor specialising in building conservation and is
currently the Technical and Research Director at the Society for the Protection of Ancient
Buildings (SPAB). He oversees the SPAB’s technical activities, which embrace advice,
publications and courses of a technical nature, as well as its supporting research. Douglas has
also worked in the public and private sectors, offering advice on historic buildings to a range
of organisations, such as the Ministry of Defence and English Heritage.

Douglas’s technical knowledge is underpinned by his formal qualifications, including an MSc
in the Conservation of Buildings, coupled with extensive practical experience. This has been
gained from leading volunteer working parties to repair old buildings, along with a project
to renovate his own Grade I-listed medieval timber-framed house in Essex. The conservation
of his 17th-century pargeting (decorative external render) was joint winner of a prestigious
Museum + Heritage Award for Restoration or Conservation.

Douglas publishes and lectures regularly on building conservation and has contributed to
various radio and television programmes. He also serves on many committees for organisations
devoted to safeguarding the historic built environment and is chairman of the Hundred
Parishes Society.

SIMON LANNON, HELEDD IORWERTH, XIAOJUN LI AND
DIANA WALDRON

Simon Lannon
Simon Lannon is a research fellow at the Welsh School of Architecture, Cardiff University, where
he has developed models and tools based on building physics principles to be used at all scales of
the built environment, from individual buildings to regional energy and emissions models. The main
focus of his research has been the development of software to model the energy use and emissions
for large urban areas using geographic information systems (GIS) and simulation software.
Heledd Iorwerth
Heledd Iorwerth is a researcher at the Welsh School of Architecture, Cardiff University, with a background in mathematics and building physics. Her interest lies in the use of GIS and statistical data to aid in modelling energy use at an urban and regional scale.

Xiaojun Li
Xiaojun Li is a researcher at the Welsh School of Architecture, Cardiff University. She has an architectural background, and has been involved in a series of projects on low carbon built environment. Her research interest lies in integrative design, and environmental performance prediction through simulation tools at a building or community scale.

Diana Waldron
Diana Waldron is a researcher at the Welsh School of Architecture and the environmental sustainability officer for the Sustainable Building Envelope Demonstration Project (SBED) at Cardiff University. Her research projects and interests have been mainly focused on finding strategies to improve the sustainable development of the built environment. She has been assisting with the development of dynamic simulation models and software tools for energy use in buildings.

The four co-authors have been researching the built environment as part of the Smart Operation for a Low Carbon Energy Region project, and the Low Carbon Environment project supported by the European Regional Development Fund through the Welsh Government.

OLIVER SMITH

Before founding 5th Studio, Oliver had worked with Sir James Stirling and then Sir Richard MacCormac on a number of international and national gallery, museum and higher education projects.

For a period of over 12 years Oliver combined practice with studio teaching at the University of Cambridge School of Architecture, focusing on attitudes to materiality and construction. This research has been extended through the practice’s work to develop a critical approach to sustainable construction and in particular to the adaptation of existing fabric.

Recent project work at 5th Studio includes the award-winning low-carbon projects at St Catharine’s College, Russell Street, and the Wolfson Flats, Churchill College in Cambridge, which have established the practice’s reputation for innovative new build and retrofit housing.

Current projects in Oxford, London and Cambridge are developing this approach over a wide range of projects, at scales from minor works to campus master-planning and urban infrastructure. Oliver is also leading the highly sustainable refurbishment of the Grade I-listed buildings at New Court in Trinity College Cambridge.
The evaluation of concerns regarding climate change can be seen to emanate from, and add weight to, a wide range of political and theoretical agendas. The aim of the first part of this book is to present a diverse range of interests and perspectives that are generated through historical, theoretical and practical research and experience. Certain conclusions overlap and others diverge: the reader is invited to join in with the debate. The chapters set out the conflicts and potential overlaps in the interests of energy conservation and building conservation. The relevance and necessary adjustment of qualitative and quantitative frames of reference are introduced alongside the various expertise of the contributors.
INTRODUCTION

The western and northern parts of the United Kingdom lie close to the normal path of the Atlantic depressions and are mostly cool and windy. The lowlands of England have a climate similar to that of the Continent: drier, with a wider range of temperatures than in the north and west. However, the winters are not as severe as those on the Continent. Overall, the south of the United Kingdom is usually warmer than the north, and the west is wetter than the east. The more extreme weather tends to occur in the mountainous regions, where it is often cloudy.¹

In the broadest of terms, the inhabitants of these islands would have recognised this modern description of the climate of the British Isles at any moment in the last four centuries. They would also have been accustomed to the vagaries and unpredictability of the weather, with the changes from hour to hour and day to day that we continue to endure. This is the background against which the following narrative is set, in which we trace the way in which British architecture has been shaped by the climate and, reciprocally, how it provides us with a vivid, alternative climate history.

HARDWICK HALL AND THE CLIMATE OF SHAKESPEARE’S ENGLAND

Hardwick Hall (Fig 1.01), with its tall, glassy facades and clusters of chimneys seen high above its monogrammed parapets, stands on a hilltop in the middle of England. Completed in 1597,
project at Kensal Rise in west London by Maxwell Fry, who was one of the leading English Modernist architects. The footprint of a demolished gasholder that formerly occupied the site determined the circular form of the plan, but the classrooms and outdoor play areas of the school are scrupulously orientated towards the sun (Fig 1.24).
FABRIC HEAT LOSS (U-VALUES)

SPAB building
The SPAB’s research began at its own traditionally built headquarters building in London’s Spitalfields. The property is Grade II-listed and originated as a silk merchant’s house in about 1740 (Fig 4.02). Glasgow Caledonian University monitored heat loss through the rear wall for the Society. The aim was to establish the thermal performance of the solid brickwork as part of a wider energy audit. This would inform decisions on work to make the building more energy efficient.

The study determined the *in situ* U-value of the wall. A U-value is a measure of heat loss through a building element, such as a wall, roof or window. It is expressed as watts per metre squared kelvin (W/m²K). The higher the U-value, therefore, the worse the thermal performance of the building envelope. By contrast, a low U-value usually indicates high levels of insulation.
In this section, a range of contributors discuss their responses in practice to the questions of sustainability and conservation. Two of the contributors discuss the long-term strategies developed while working with academic buildings in the UK and the US respectively. The other chapters offer examples and discussion in the context of domestic and ecclesiastical buildings.
AIRTIGHTNESS

Airtightness refers to the degree of air leakage through the fabric of a building (for example, via gaps in floors, walls and windows). Airtightness testing is a way of quantifying this. In addition to providing an overall indication of airtightness, such testing can apportion the contribution made by leaks from different sources in a building. This is particularly helpful for pinpointing elements that would benefit from draughtproofing.

Airtightness may be expressed as m$^3$ of airflow per hour per m$^2$ of building enclosure (m$^3$/h.m$^2$) where there is a 50Pa difference between the air pressures internally and externally. Rather than relating airflow to the surface area inside a building, airflow is often related to the building’s volume and expressed as air changes per hour (ach @ 50Pa), since this can be easier to comprehend. If this figure is divided by 20, it gives an approximation of air changes per hour at normal pressure.

Testing of the properties in the SPAB building performance survey is being carried out by Green Footsteps of Cumbria in line with the methodology set out in the Air Tightness Testing and Measurement Association’s (ATTMA’s) Technical Standard L1 (2010). The procedure involves temporarily covering or closing any deliberate points of ventilation, such as fireplaces, boiler flues or extractor fans. A pressure difference of 50 Pa is created between the inside of the building and outside using a fan/fans inserted into a suitable external opening (for example, a doorway). The airflow through the fan(s) is then measured.

Testing assists in identifying individual paths of air leakage since it exaggerates the normal cooling from air infiltration on the building fabric. Either infrared thermal imaging or smoke is used to locate leaks, depending, respectively, on whether the fan is depressurising or pressurising the building. It is possible to apportion the approximate air leakage associated with a particular element by comparing the airflow readings for it sealed and unsealed.

The airtightness results for the three buildings tested so far as part of the building performance survey are shown in Table 4.2. The tests have yielded a wide range of results before and after renovation. Some compare favourably with the limiting airtightness for new

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-renovation</th>
<th>Post-renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Airtightness m$^3$/h.m$^2$ @ 50 Pa</td>
<td>Air changes ach @ 50 Pa</td>
</tr>
<tr>
<td></td>
<td>Airtightness m$^3$/h.m$^2$ @ 50 Pa</td>
<td>Air changes ach @ 50 Pa</td>
</tr>
<tr>
<td>Drewsteignton</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Riddlecombe</td>
<td>5.5</td>
<td>7.2</td>
</tr>
<tr>
<td>Shrewsbury</td>
<td>11.4</td>
<td>15.7</td>
</tr>
<tr>
<td>Skipton</td>
<td>16.9</td>
<td>14.8</td>
</tr>
</tbody>
</table>
Conclusions

Oriel Prizeman

It is feasible to imagine that the political and ideological values of sustainability and conservation are interchangeable. However, the philosophical starting points can be very disparate. Arguments are often won by the reassociation of prejudices and can span the political spectrum. In the 21st century, Libertarian fears over protecting energy security and a reassertion of responsibility towards future generations can take the place of the CND campaigners of the 1970s. Regulating the lever that swings between control and risk in this context aims to use theory developed in a scientific manner to drive policy and practice, which somehow is expected to take heed of the protected species of traditional knowledge at the last minute.

The ICOMOS Venice Charter 1964 [Article 9] extended the William Morris/SPAB principle that restoration ‘must stop at the point where conjecture begins’ to a global audience. Today, UNESCO acknowledges a gulf in policy regarding conservation and sustainable development, and a working group is addressing the issue in 2015. Fukuyama, in his recent study of political order and the globalisation of democracy, notes: ‘The economic, social, and political dimensions of development proceed on different tracks and schedules, and there is no reason to think that they will necessarily work in tandem.’ This is relevant to the globalisation of policy regarding heritage and sustainable development. In the context of UNESCO, it is relevant to question whether policy is still entirely dominated by European colonial and patriarchal models. China’s growth, not America’s, is always referred to as the evil force of environmental risk to future generations.

The critical importance of economic and environmental contexts is reflected by differing perspectives presented in these few western texts. Equally, historic reflections on heritage, and pride or shame associated with the past, influence the prospects of physical artefacts. The key point in the field is that all responses, judgements and approaches are specific to a place and time. Principles are useful where regulations are not. It is not insignificant to note that ICOMOS has struggled to revise its simple guidelines to accommodate concerns of sustainability. The enormous quantity of detail required for assimilation in the first steps of
Principles of conservation and sustainability are easily married but often at odds for architects under increasing pressure to address the energy needs of older buildings. By incorporating UK and international case studies with more theoretical essays, this book seeks to identify overlaps in the interests of energy and building conservation.

The varied expertise of the contributors – architects, surveyors, consultants and academics – demonstrates the use of qualitative and quantitative frames of reference. The second part of the book showcases sustainable domestic and non-domestic heritage projects, translating the challenges of the preceding research into varied methods that practitioners can use to question and review their everyday work.

The book will appeal to all architects, building professionals and designers working with traditional buildings and will enhance readers’ ambitions, so that they feel equipped and inspired to work with old buildings sensitively, creatively and sustainably.

DR ORIEL PRIZEMAN is a RIBA Accredited Conservation Architect trained at Cambridge and the Architectural Association. She ran her own practice focusing on work to listed houses in the Cambridge area from 1996–2012 and established a new MSc in Sustainable Building Conservation at the Welsh School of Architecture, Cardiff University in September 2013.

“This book illustrates the dilemma between ‘do nothing’ and ‘do everything possible’, with telling lessons in how great architecture from the past was designed to work with rather than fight the environment, and how well-informed sensitivity can both protect and enhance our most precious built heritage.”

ROBERT FRANKLIN, RIBA SCA

“A compendium of top notch theoretical and practical expertise on the inherent sustainability of existing buildings, and an ideal companion to British Standard 7913 on historic building conservation. This is an impressive and important rallying call for architects to take pride in their role as guardians of our built heritage.”

DR SEAN O’REILLY, DIRECTOR, THE INSTITUTE OF HISTORIC BUILDING CONSERVATION (IHBC)