The Circadian House: Hawkes House - Designing for Ageing

This paper is the result of a joint presentation by the authors at last year's Research Symposium, *Design for Ageing*, at which they collaborated in a discussion of a house in Cambridge. Although built in 1991, Hawkes House anticipates Circadian principles and combines these with the dwelling needs of ageing occupants. This experience prompted the notion of further exploring the relevance of circadian design in this field.

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Introduction

The idea of the 'Circadian House' was first proposed by the VELUX company of Denmark in 2013.[1] The aim is to provide,

> *" … a comprehensive vision to realize healthy homes that support the different biological needs of their occupants, in particular including their circadian rhythms and sleep-wake cycles."*

The VELUX report, *Circadian House: Principles and Guidelines for Healthy Homes*, derived from a series of five workshops, held in Copenhagen between November 2012 and August 2013, at which authorities from biological and social science, building science and architecture and planning discussed how the human need to experience the diurnal and seasonal circadian cycles might be translated into architectural design principles.

The *Principles and Guidelines* of the VELUX study are conceived to be applicable to dwellings of all types from single-family houses to apartment buildings and to be relevant to both new and existing dwellings. The present document has its origins in the RIBA Research Symposium 2014, *Design for Ageing*[2], at which the authors collaborated in a discussion of a house in Cambridge that, although built in 1991, combines circadian principles (protocircadian?) with the dwelling needs of ageing occupants. This experience prompted the notion of further exploring the relevance of circadian design in this field.

The Circadian Idea - Fundamentals

Circadian rhythm is defined as:

> *" … a characteristic periodic change in a living organism or life-related process. A circadian rhythm is an approximate daily periodicity, a roughly 24-hour cycle in the biochemical, physiological or behavioural process of living beings. Circadian rhythms may be influenced by optical radiation (light)."*[3]

The principles and factors proposed by the VELUX studies for the design of a *Circadian House* are:

Key Principles

- Live in balance with nature - A house whose space and occupants can adapt to changing conditions (daily, seasonal) and needs.
- Adaptability - A house whose space and occupants can adapt to changing conditions (daily and seasonal) and needs.
- Sensibility - A house that provides protection against harmful substances, which humans cannot sense, and allows freedom to control parameters that can be sensed.

Key Factors

- Variation: The focus on nature's cycles implies that the indoor environment should vary in time and space rather than target uniformity or non-variability.
- Stimulation/absence of stimulation: The level of stimulation from environmental factors (light, sound, air, temperature) should be higher during day than night.

- Outdoor/indoor relation: Outdoor and semi-outdoor areas are designed to be inspiring and easily accessible; and occupants are able to follow (changes in) outdoor conditions in all main living areas of the house.
- Light/darkness: Exposure to high levels of daylight is needed in the main living areas of the house during daytime, with special attention to the rooms that are mainly used in the morning, whereas the bedrooms need to provide complete darkness at night time.
- Electrical lighting should follow, support and supplement change and variation in the light spectrum and intensity through the course of the day and distribution in space.
- Cool/warm: The house should provide temporal and spatial variations in the thermal environment that are logical and follow, to a certain extent, outside temperature variations.
- Silence/sounds: The presence of sound and contact with sounds from outdoors are desired during daytime, whereas quiet spaces are needed at night time.
- Rest/activity: The house design should inspire the occupants to be active, but also have areas for rest and restitution.
- Flexibility related to the seasons: The use of outdoor and semi-outdoor spaces should be stimulated outside the heating season.
- The occupants should be able to control the systems that influence parameters that can be sensed, e.g. lighting level, air quality and indoor temperature.

Circadian Design for Ageing: Hawkes House – A Case Study

The aim of the VELUX project was to establish a basis for the application of circadian principles in the design of dwellings for all ages. Our intention in this paper is to examine the relationship between these general principles and the specific requirements that apply to the dwellings of older people.

The Hawkes House at Cambridge was designed and built in 1991 by architects Greenberg and Hawkes as the residence of one of the partners and his wife. They were then in their 50s and expected that the house would be their home for the rest of their lives. They have now spent 24 years in the house and, therefore, are in their 70s. They and the house have matured together.

The design of the house clearly pre-dates the development of the formal principles of the Circadian House, but it is suggested that it anticipates many of the key ideas and the experience of almost a quarter of a century of living there constitutes an extended ‘post-occupancy case study’ of ‘Circadian’ living. Dean Hawkes was one of the contributors to the VELUX research project. His contribution was to a workshop on the architectural context. In this he illustrated a sequence of British house designs in which ‘protocircadian’ ideas were exemplified.

The majority of these examples derived from the research for the book, *Architecture and Climate: An Environmental History of British Architecture 1600 – 2000*.[4] The first Circadian Principle, to *Live in balance with nature*, is most fundamentally realized through the way in which a building positively responds to the climate in which it is set. In *Architecture and Climate* it is shown that architects of great significance in Britain have, for many centuries, understood and responded to climate in creating rich and appropriate environments for living.

Hardwick Hall, Derbyshire, 1597

The first historic example was the remarkable Hardwick Hall in Derbyshire.

Fig. 1 Hardwick Hall from the south-west.
The Countess of Shrewsbury's apartments were on the south-west corner of the first floor.

The house was built, to the design of Robert Smythson, between 1590 -1597 as the home of Elizabeth, Countess of Shrewsbury. Familiarly known as Bess of Hardwick, she moved into the house, on 4th October 1597, thought to have been her 70th birthday.[5] It has been suggested that the location of her private apartments, on the first floor at the south-west corner of the house, was carefully chosen to provide the most agreeable, sun-lit environment for an elderly occupant. The enormous bay windows, that characterize the entire expression of the house, project a full awareness of the diurnal and seasonal progression of light throughout the entire house and bring a particular sense of this to these special rooms, anticipating the Circadian House by four centuries.

Hawkes House, Cambridge, 1991

This great house at Hardwick is, of course, far removed from the needs and expectations of present day older occupants, but indicates that special attention to their housing needs has a long and architecturally significant precedent. Four centuries later the Hawkes House at Cambridge (Fig. 2) brings similar principles to bear on designing for ageing in much more modest circumstances.

Fig. 2 Hawkes House, Cambridge. Entrance front from the west.

The importance of orientation in relation to the sun's movement across the sky is common to both designs. The plan of the house (Fig. 3) arranges most of the principal rooms so that they face south across the narrow suburban site.

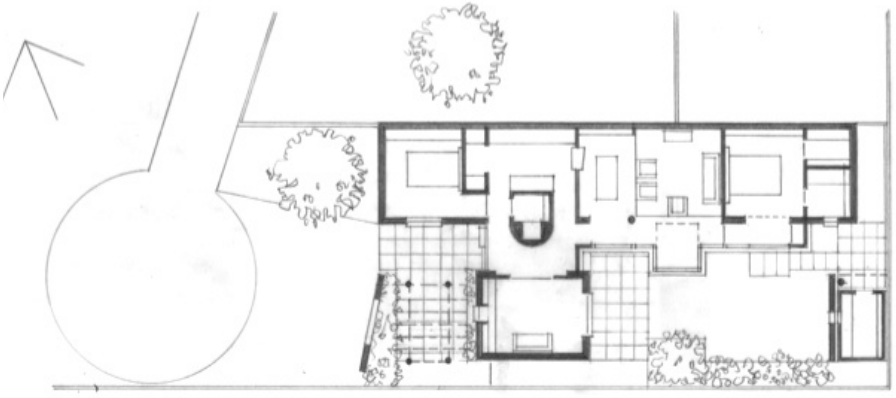


Fig. 3 Hawkes House. Plan.

The house has a main block that is built on the northern boundary of the site and contains, reading from west to east:

- Guest room
- Kitchen
- Shower room
- Living room, with dining
- Main bedroom with en suite bathroom

To the south of the entrance is a study wing that encloses the courtyard garden that is the focal point of the entire plan. At the east end of the garden is a small second detached study, built in 2002. The principal spaces, living room and main bedroom extend are connected to the enclosed garden by a glazed 'gallery', which includes a tall bay window. The studies have east and/or west orientations. The entrance to the house is between the two wings through a sheltered courtyard with a pergola.

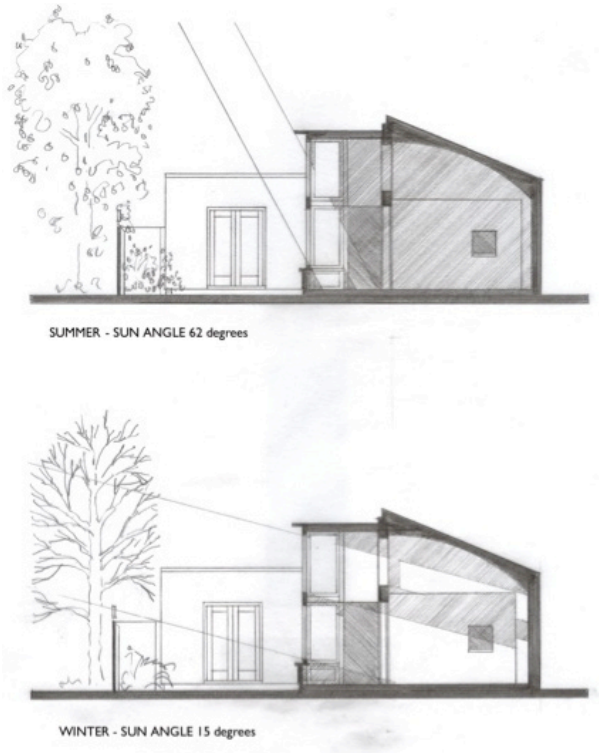


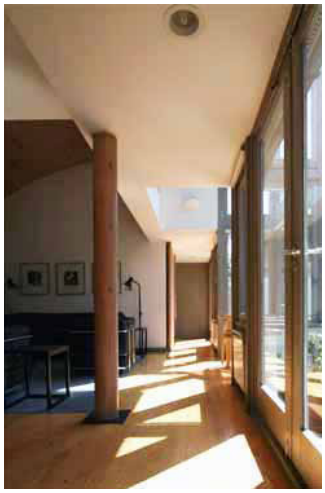
Fig. 4 Hawkes House, Cambridge.

In northerly latitudes the sun's altitude varies greatly between summer and winter. At Cambridge, just over 52° N, the altitude at noon at the summer solstice is approximately 62° and at the winter solstice is close to 15°. The effect of this in the Hawkes House is shown at Fig. 4.

Cross sections through the living room bay window showing sun angles at the summer and winter solstices.

We should first note the contrast between the sun's penetration into the house at the two seasons. In summer it is restricted to the southern edge of the room whereas in winter the low rays reach the back wall. The effect of this is to transmit an awareness of the progression of the seasons to the inhabitants. The entire environment of the house is the product of this, both quantitatively and qualitatively.

In summer the interior remains shady and cool, whilst the outlook is on to the bright garden, itself partially shaded by the hawthorn trees to the south. At this season the garden, which is accessible by french windows from the living room, study and main bedroom, is a natural extension of the house. In the winter months the low sun brings bright light and pleasant warmth to the house.[6] The effects of this are illustrated at Figs. 5 & 6 below.




Figs. 5 & 6 Hawkes House living room,the seasons.
Left: Summer, Right: Winter.

The living room is quite complex spatially, with a half-vaulted ceiling over the main sitting area and a lower area for the main dining table. The plaster surfaces are painted white, but the ceiling vault and much of the floor are natural timber, with a soft, blue carpet for the main seating area under the vault. A bay window plays an important role in the enjoyment of the room (Figs 7 & 8). It is 3.6 metres tall and captures sunlight throughout the day at all seasons. It contains a small table with chairs where meals for two, breakfast, lunch and dinner, may be enjoyed in close contact with the garden and in the warmth of the sun. On hot summer lunchtimes a simple roller blind easily provides shade. The bay also attracts other uses; reading, sewing, drawing and the like throughout the day. It is a place that attracts inhabitation and use - function *following* form.

Fig. 7 Hawkes House, bay window from the garden.

The other rooms of the house are smaller and much simpler than the living room, but they demonstrate the same concern to provide an environment that supports the needs of the occupants as they go about their daily lives. The kitchen is conceived as a functional place, rather than as an extension of the living areas. It has a similar ceiling vault to the living room. This brings volumes of daylight from a high clerestory window and also provides natural ventilation through an electrically operated opening light. The light is highly functional, with strong reflections from the white cabinets, but the southern exposure of the clerestory also provides a dynamic, ever-changing light as the days and the seasons progress. A low level opening connects the kitchen directly to the living room for serving, but also for visual contact (Figs. 9 & 10).

Fig. 8 Hawkes House, bay window with morning sunlight.

The study in the main house has windows to east, french windows to the garden, and west, a small ‘view’ window above the fitted desk that looks into the sheltered entrance courtyard. This means that the room remains comfortable on the hottest of summer day by avoiding solar gain at midday. The floor is carpeted to match the sitting area of the living room. The house’s only television set is kept here so that the room has a secondary use for viewing in the evening. In winter it is economical to heat. The second study, which was built after the owner retired in 2002, is detached from

Figs. 9, 10 & 11 Hawkes House. Left: kitchen showing clerestory window, Middle: kitchen showing opening to living room, Right: view into the garden from the second study window

the house and, although small, is intensively used for continuing academic research. It has a wall of bookshelves and a built-in desk and is lit by a west-facing clerestory and a lower openable window that provides natural ventilation and a view of the garden (Fig. 11).

Finally, in this description, the bedrooms. The guest room, which is used only by occasional visitors, is the simplest room in the house. It contains just a bed and a complete wall of wardrobes that provide guest hanging space, plus storage for the owners. It has a small, south-facing window that looks into the entrance courtyard. Privacy and blackout are provided by a simple roller blind. In future, should the need arise, it could provide accommodation for a live-in carer.

The owners' bedroom is beyond the living room, at the east end of the house. This has an en suite bathroom and a walk-in closet. It is quite simple containing just a bed, bedside chairs and a wall of bookshelves (Fig. 12). The bedroom is approached from the living room via the glazed 'gallery', which becomes a 'vestibule' to the main space. Privacy and blackout are provided by a floor-to-ceiling curtain at the threshold to the room. There are french windows leading from the 'vestibule' into the garden.

Fig. 12 Hawkes House, nighttime view of the principal bedroom from the garden.

Both bedrooms have a deep grey carpet to differentiate these nighttime places from the day rooms of living and study, with their blue carpets. At daytime, with the curtains open, it is possible to see onto the garden from the bed with complete privacy from adjoining property.

The house has a gas-fired central heating system, with a condensing boiler and an efficient and simple control system. The construction achieves a U-value of 0.2 W/m2/ °C. In combination with the passive solar design, the house is frugal in its energy consumption and, importantly, substantially keeps energy costs down.

The artificial lighting is designed to provide diverse possibilities, with zoned control and dimmer switches. This allows the ambience to be varied according to activity and mood. Since the house was first built all of the luminaires have been fitted with low-energy lamps and provision has been made to add further standard lamps near reading seats, as the owners' visual acuity has declined with age.

Testing Circadian principles

Although built more than 20 years before the formulation of Circadian principles, the Hawkes House meets the three 'Key' principles of Circadian design. Its form, materiality and detail allow its occupants to 'live in balance with nature'. The generous southern exposure establishes a continuing sense of the diurnal and seasonal cycles. After 24 years of occupation the house has proved its *Adaptability* to changing conditions and, crucially in the context of *Design for Ageing*, to the changing needs of its owners as they have themselves aged. On the criterion of *Sensibility*, the surroundings of the Cambridge suburbs are relatively benign, with little that is aggressive in the environment., either physically or socially. Even so, the house creates and tranquil setting for domestic life that it has sustained for almost a quarter of a century.

Measured against the *Key factors* of Circadian design we may report as follows:

- *Variation*. The environment of the house captures and echoes nature's cycles providing variation in time and space. It avoids uniformity and non-variability. This is particularly so in the living room, but is also achieved in the other rooms.
- *Stimulation/absence of stimulation*. The house is very responsive to stimulation from the external factors of light, sound, air and temperature during the daytime and these are less intrusive at nighttime.
- *Outdoor/indoor relation*. The small garden is directly visible from the main rooms of the house and there is direct access to it from the living room, study and main bedroom. It is enjoyed at all seasons and, in summer, becomes an important space for extended living.
- *Light/darkness*. The living room is filled with ever-changing natural light from morning to evening. Breakfast in the bay window is warmed by the easterly sun (Fig. 8 above) and the tall bay window projects low sunlight on to the end wall in the evening (Fig. 13). The bedrooms enjoy lower levels of light and are easily enclosed at nighttime.

Fig. 13 Hawkes House, evening sun on the end wall and ceiling of the living room.

- *Electrical lighting*. Through the daylight hours every room in the house enjoys excellent natural light. After dark the electrical lighting, which uses low-energy lamps throughout, is designed to allow different conditions dependent on requirements. These can vary from full room illumination for practical purposes to more subdued and intimate arrangements when these are desired. Particular attention is paid to providing good local light to aid reading for the older occupants (Fig. 14).

- *Cool/warm*. In addition to its energy-saving benefits, the 'passive solar' design of the house implicitly makes a link between the internal and external environment. Environmental diversity, both temporal and spatial, is enjoyed, in particular in the living room as the sun makes its daily and seasonal progress. In summer, the high volume of the sitting area remains cool as the high angle sun is contained at the edge of the room. In winter, the low sun reaches deep into the room bringing perceptible solar warmth.
- *Silence/sounds*. The low density suburbs of Cambridge are relatively free from intrusive sounds. These places are now well wooded and attract populations of birds whose song provides a background to life in the house, particularly in the summer when windows and french doors are open. With windows closed the interior is quiet and provides a good setting for listening to music, reading and undisturbed sleep.

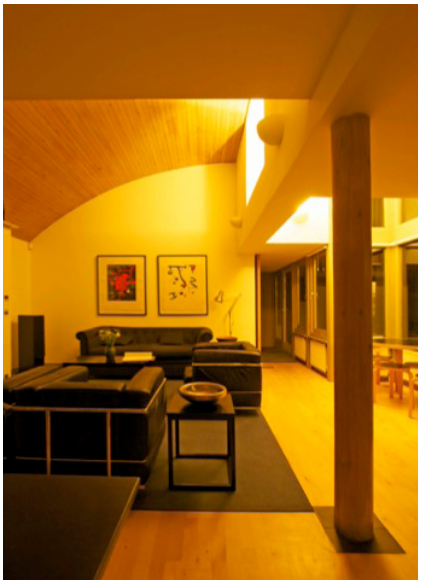


Fig. 14 Hawkes House, Living room with an intimate lighting arrangement.

- *Rest/activity*. The house is small in floor area – less than 100m^2 – but its single-storey layout provides ample space for movement between rooms and to and from the garden. The living room and main study have comfortable places to relax and the main bedroom, with its view into the garden, may be enjoyed during the daytime.
- *Flexibility related to the seasons*. The sheltered courtyard garden has a microclimate that encourages its use on sunny days in spring and autumn.
- *Control systems*. The heating controls consist of a simple thermostat located in the larger study and thermostatic valves on all the radiators. These allow flexibility in choice of temperature in the different rooms. All the light switches are carefully located in relation to the lamps they control, so that their function is intuitive. Dimmer switches on selected lamps allow light levels to be varied to suit needs and moods.

  Ventilation is principally by openable windows. These are side-hung casements and are all easily within reach. The high level window in the kitchen clerestory is electrically operated by a control switch placed next to the light switch for the room.

Generalisation and design

The Hawkes House is a one-off design conceived for individual clients. The question arises as to how this may this serve as a general model for housing for bringing *Circadian* principles to bear on *Design for Ageing?*

In this conclusion we offer the general principles that can be derived from this exercise and applied to the design of dwellings of all types, houses and apartments. We give specific attention to the following distinct aspects of design; *Orientation, The Plan, The Cross Section, Room Types, Design Detail* and *Materials and Future Adaptability*.

- *Orientation*. The most fundamental aspects of Circadian design derive from the orientation of a dwelling. The criteria of *Variation, Stimulation, Outdoor/indoor relation, Cool/warm* are all, to some degree, contingent on the relation of a building and its main rooms to a

southerly orientation (in the Northern hemisphere). At the latitude of the United Kingdom, between 50° and 60°N, the sun's path produces the wide daily and seasonal variations that are a key and desirable element of Circadian design.

- *The Plan*. It is in devising the plan of a dwelling that response to orientation is determined. An invaluable tool in this is reference to a sunpath diagram for the location. This allows the relationship between the sun and individual rooms within to be understood. This aspect of design may be easily and extensively explored using CAD tools.
- *Cross Section*. The cross section of a building is as important as the plan in understanding the penetration of sunlight and, hence, the enjoyment of the elements of Circadian design. The simple comparison of summer and winter conditions shown for the Hawkes House at Fig. 5, is easily made and more extensive analysis is readily possible with CAD tools.
- *Room Types*. The example of the Hawkes House illustrates how the rooms of even a small dwelling may be designed to provide specific environments related to their use. This is achieved in part by giving attention to the key concerns for orientation, the plan and cross section, but the key lies in the analysis made of the differing needs of daytime and nighttime inhabitation and the range of activities that occupants are likely to carry out in their daily lives. This is illustrated in the quite complex design of the Hawkes House living room, but is equally realized in the essentially simple nature of the bedrooms.
- *Design Detail and Materials*. Some of the most important contributions to achieving the qualities of Circadian design come from attention that is paid to the detail and materials of a building. The creation of small, aedicular places, such as the Hawkes House bay window, may contribute a great deal to the experience of a room, extending its use and, in this case, achieving a richer relationship between inside and outside. The vaulted ceilings over part of the living room and the kitchen contribute to the thermal, luminous and acoustic environments in these rooms. The small opening between the living room and the kitchen is not only practical, as a serving hatch, but also establishes a visual link between the two rooms that has considerable social and psychological value. The materials and finishes of the interiors of rooms play a vital part in supporting their inhabitation. In small dwellings it is usually good to have a simple background – here in the general use of white-painted plaster for most of the walls and ceilings. This may then be 'fine-tuned' by using small areas of strong colour for walls and carpets, introducing natural materials for floors or ceilings. This then forms a background into which the occupants may place their own possessions, furniture, pictures and so on.
- *Future Adaptability*. The single storey house, with its open arrangement of spaces and few internal divisions, makes it inherently easy to inhabit as the owners grow older. Specific physical adaptations that could easily be made, if needed, would include raised access to the external doors for future wheelchair use. This would be particularly valuable in maintaining access to the garden, since this plays such a central part in the daily life of the house. As we age we come to inhabit a reduced 'environmental envelope'. This is that we tend to be less tolerant of extremes of heat, light and sound. We feel both cold and heat, we require higher light levels for activities such as reading, but are more sensitive to glare and our hearing becomes less good. As described above, the Circadian environment of the house meets many of these needs. This could, however, be fine tuned by refining the heating controls and adding further light fittings.

Final thoughts

The 'Key Principles' of Circadian design are to *Live in Balance with Nature*, to design for *Adaptability* and to achieve *Sensibility*. By these we may ensure that the houses we build are *healthy*, in the widest meaning of the term. These principles are particularly relevant when designing houses for an ageing population. This *Case Study* of the Hawkes House, shows how a house designed in 1991 to 'proto-Circadian' principles has sustained the lives of its two occupants for almost a quarter of a century. As one of those two occupants I can say that our everyday lives are enhanced as, sometimes subliminally, but sometimes quite consciously, we sense and observe the movement of the light from morning to night and from summer to winter and back again. With the light we also enjoy the warmth of the sun, particularly when it shines deep into the house in the winter months.

This is the most potent mechanism by which we make connection with nature and its effects are profound. The translation of *principle* into *form* is a difficult task in architecture. We hope this study helps to show the way.

Endnotes

1 Velux, *Circadian House: Principles and Guidelines for Healthy Homes*, Copenhagen, November 2013.

2 The RIBA Research Symposium 2014 was held at the RIBA in London on 18th November 2014. A detailed report of the event is, Matthew Barac, 'When we're 65'. *RIBA Journal*, March 2015.

3 ISO 16817:2012.

4 Dean Hawkes, *Architecture and Climate: An Environmental History of British Architecture 1600 – 2000*, Routledge, London and New York, 2012.

5 See Mary S. Lovell, *Bess of Hardwick: First Lady of Chatsworth*, Little Brown, London, 2005, p. 407.

6 The house was also designed as an essay in 'Passive Solar' heating. The direct penetration of sun in the winter months provides effective warmth for many daylight hours. This supplements the conventional heating system bringing useful savings in running costs and in environmental impact.

Acknowledgements

This paper would not have been possible for Anne Dye and Alex Tait who organised the 2014 RIBA Research Symposium, Design for Ageing, and invited the authors to join forces to share their extensive knowledge and insight. This study is published on the anniversary of this influential Research Symposium.

We should also like to thank the VELUX Company for initiating the idea of Circadian Design and for offering their support to our project.

Fig. 15 Dean and Anne Dye, RIBA.

About the Authors

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. His research is in the field of environmental design in architecture. His books include, *The Environmental Imagination (2008)* and *Architecture and Climate (2012)*. His buildings, in partnership with Stephen Greenberg, have won four RIBA Architecture Awards. In 2010 he received the RIBA Annie Spink Award in recognition of his contribution to architectural education.

Jeremy Porteus is founder and director of the Housing LIN. He is co-author of the 2012 All Party Parliamentary Group on Housing and Care for Older People inquiry report, *'Housing our Ageing Population: Plan for Implementation'.*

About the Housing LIN

The Housing LIN is the leading 'learning lab' for a growing network of housing, health and social care professionals in England and Wales involved in planning, commissioning, designing, funding, building and managing housing, care and support services for older people and vulnerable adults with long term conditions.

Previously responsible for managing the Department of Health's Extra Care Housing Fund, the Housing LIN is called upon by a wide range of statutory and other organisations to provide expert advice and support regarding the implementation of policy and good practice in the field of housing, care and support services.

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