



Design guide for 6-star energy equivalence housing

A guide to assist with achieving a 6-star house

May 2011

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1 Purpose

This guide has been prepared to assist housing designers and architects in implementing Queensland's 6-star energy equivalence housing requirement. A case study design in each of Queensland's four *climate zones* has been used to identify suitable design strategies for cost-effective compliance given the range of options available.

This guide should be read in conjunction with the Guideline for Queensland Development Code MP 4.1—Sustainable buildings.

2 Design considerations

A house's energy equivalence rating is determined by the design of its building shell—its roof, walls, windows and floors. The rating is out of ten stars, with more stars indicating a more energy efficient and comfortable house.

2.1 Design principles

The objective of the energy efficient housing standards is to use a range of passive design features that can improve the energy efficiency of the dwelling and to create a more naturally comfortable home. This will minimise the need for artificial cooling and heating. In Queensland, key passive design principles that can be applied to house design include:

- northern orientation of living rooms
- minimising east and west facing walls
- wider eaves and awnings for shading
- natural ventilation through windows and doorways
- increased insulation in the roof space and walls
- treated glazing, particularly for windows facing west and north-west
- light coloured roof and external walls
- ceiling fans in living areas and bedrooms
- well-designed and located outdoor living areas e.g. decks, verandahs and patios.

Proper integration of passive design features will influence comfort level and energy efficiency of a house. No single feature alone can maximise a home's thermal performance, and in some cases different building features can significantly affect the performance of others.

It is also important to undertake a site analysis so that homes can be specifically designed for local climatic conditions, i.e. micro-climate factors such as topography, solar access (including sun paths), adjacent shading and local climatic data (average monthly temperatures, humidity, rainfall, wind speed and direction)

3 Background

Good design and energy efficiency is integral to a sustainable house, which uses as little energy and water as possible and can accommodate people's changing lifestyle and circumstances.

The 6-star minimum energy equivalence requirement for new housing was introduced on 1 May 2010. This requirement is contained in the Queensland Development Code MP 4.1— Sustainable buildings (QDC) and the Building Code of Australia (BCA). This standard applies to new houses and townhouses (class 1 building's) and their enclosed attached garage or carport (class 10a buildings). It also applies to alterations or additions to existing houses and townhouses such as extensions, renovations or re-locations. Where there are multiple dwelling units (class 1a) such as duplexes, villas, townhouses and terrace houses, each dwelling unit needs to be assessed as a separate building and must comply with the 6-star requirement.

Optional credits towards the 6-star housing requirement are available with the inclusion of an outdoor living area, such as a verandah, deck or patio (up to 1 star using minimum QDC specifications), and/or a photovoltaic (solar) energy system (1 star with a minimum 1 kilowatt capacity). If using these optional credits as part of the house's design, minimum baseline building requirements apply. These minimum baseline building requirements depend on the climate zone and assessment method used. The examples used in this guide do not include the optional credit available for adding a photovoltaic (solar) energy system as the focus of the guide is to encourage energy efficient housing through passive design.

While housing design can assist with minimising energy and water bills, it is important to recognise that occupant behaviour also plays a key role e.g. leaving an air-conditioner running when sitting outside on a deck.

3.1 Climate and house design

Given the wide variety of climates in Queensland, the same house design and specifications will not perform equally well in all of Queensland's climate zones. For example, a design specifically adapted for climatic conditions in Cairns is unlikely to be appropriate for Toowoomba.

The Queenslander housing style is well-recognised as part of Queensland's lifestyle and culture. Its key design aspects, including elevated suspended timber flooring and the use of lightweight construction provide time-proven benefits that suit our unique climate.

This guide presents a case study for a modern Queenslander—a house of lightweight construction material with an elevated suspended floor.

The design has been varied to suit the prevailing climatic conditions in each of Queensland's four climate zones in the following locations:

- Townsville (climate zone 1—tropical)
- Sunshine Coast (climate zone 2—subtropical)
- Charleville (climate zone 3—hot arid)
- Toowoomba (climate zone 5—warm temperate).

Refer to Appendix 1 for the location of Queensland's climate zones under the BCA (these are based on local government areas).

A Designer's Toolbox of passive design features is presented in each of the four case study designs. These provide no cost or low cost options that could influence the cooling and heating aspects for the house and its overall energy efficiency for compliance with the 6-star rating.

3.2 Compliance options considered

The QDC provides flexibility in design to achieve compliance with the 6-star housing standard. Designers need to decide the most suitable assessment path for the design given its location. The most commonly used compliance options are elemental and software, or a combination of both. Peer review (expert panel) and verification (to a reference building) are also available as compliance paths under the QDC and BCA, but are less commonly used assessment methods and have not been used in this guide.

Each design must be assessed on its merit inclusive of its location, orientation, design and construction materials. It is therefore recommended to discuss your house's proposed design and assessment method with a building designer or architect, a building certifier and house energy assessor early in the design process. They will be able to advise on the most suitable compliance method for the design.

To illustrate how the QDC provides flexible compliance methods, the following three options are used in this guide:

- (1) **Elemental (BCA 2010) only**—achieve compliance using only the 6-star elemental (also known as the deemed-to-satisfy (DTS)) provisions of the BCA 2010 (Volume Two, Part 3.12—Energy Efficiency). The elemental (DTS) provisions provide a prescriptive approach and are based on Queensland's four climate zones. The provisions vary according to different regions to account for energy efficient design standards suitable to each climate zone.
- (2) **Elemental (BCA 2009) plus QDC optional credits**—achieve compliance using a combination of the BCA 2009 elemental (DTS) prescriptive provisions (5 stars) plus the optional credits available under the QDC with the inclusion of a covered outdoor living area with a compliant ceiling fan (1 star).

- (3) **Software only**—achieve compliance using only computer software to gain a minimum 6-star rating. Software used can be BERS Pro¹, AccuRate² or FirstRate5³ (all accredited under the Nationwide House Energy Rating Scheme (NatHERS), and with a calculation method complying with the Australian Building Codes Board Protocol for Housing Energy Rating Software. This should be undertaken by a trained house energy assessor. The use of software allows for more flexible design options than the elemental (DTS) prescriptive provisions as trade-offs can be made between design features.

With software, house designs are assessed for their energy efficiency performance relative to the nearest reference location. Each reference location uses a climate file, which contains averaged climatic data from at least 30 years of recorded data from the Bureau of Meteorology. There are currently 12 climate files for Queensland (compared to the four climate zones defined by the BCA). Refer to Appendix 2 for locations of Queensland's climate files.

Where there are two proximate climate files, such as Brisbane and Amberley, designs should be assessed using the most appropriate climate file for the site to best account for sub-regional climatic differences. For example, sites located closer to coastal areas would be assessed against the Brisbane climate file and more inland areas assessed against the Amberley climate file.

Another compliance method that could be considered is software plus QDC optional credits. This would use a combination of software to achieve the baseline building rating (depending on climate zone) plus the optional credits available under the QDC.

Baseline building rating and optional credits

For houses and townhouses using optional credits towards the 6-star housing requirement, a baseline equivalence star rating for the building shell is required under the QDC. The baseline rating depends on the assessment method used.

Software assessment method:

The baseline building requirement depends on the climate zone:

- minimum 4.5 stars in climate zones 1 (tropical), 2 (subtropical) and 5 (warm temperate)
- minimum 5 stars in climate zone 3 (hot arid).

Note, that Queensland does not have a climate zone 4.

The difference between minimum star ratings required is that more energy is needed to heat and cool dwellings located in climate zone 3, and this can be rated by software.

¹ provided by Solar Logic (www.solarlogic.com.au)

² provided by Hearne Scientific Software (www.hearne.com.au)

³ provided by Sustainability Victoria (www.sustainability.vic.gov.au)

Elemental (DTS) assessment method:

The baseline building requirement is 5-star energy equivalence through the use of the BCA 2009 (Volume Two, Part 3.12). This requirement applies statewide as the BCA 2009 provisions only allow the design of a 5-star house.

4 Case study design

The case study design is considered to reflect a contemporary Queenslander. The base house design specifications have been varied to suit prevailing climatic conditions using good passive design strategies relevant to the climate zone. This means that orientation, natural ventilation, insulation and appropriate shading have been incorporated into the home's overall design.

The 3-bedroom, single-storey design uses lightweight construction materials, such as timber and weatherboard, with insulated walls and roof spaces. The northern and western facing walls are well-shaded by a combination of roof eaves and landscaping. For all Queensland locations, good shading assists in protecting the home from the direct impact of summer sun.

The garage is located on the south-western corner as it is a non-habitable room and can reduce heat loads from hot summer afternoon sun. For coastal locations (Townsville and Sunshine Coast) the south-east living areas are well-shaded and face the north or east to capture summer breezes.

Sloping sites that require cut and fill to provide an even ground-level for the construction of a new home are becoming prevalent in housing estates across many areas of Queensland. Consequently, houses designed with suspended flooring are seen as an alternative option to minimise the amount of cut and fill on sloping sites, and this technique is becoming an important design response.

This case study is specifically designed to suit a sloping site using suspended timber flooring, which can minimise the impact on the local natural environment. However, the design could also be adapted to suit a slab-on-ground house. A 3-D model of the base house design is presented in Figures 1a and 1b.

Figure 1a: Front entry of case study house

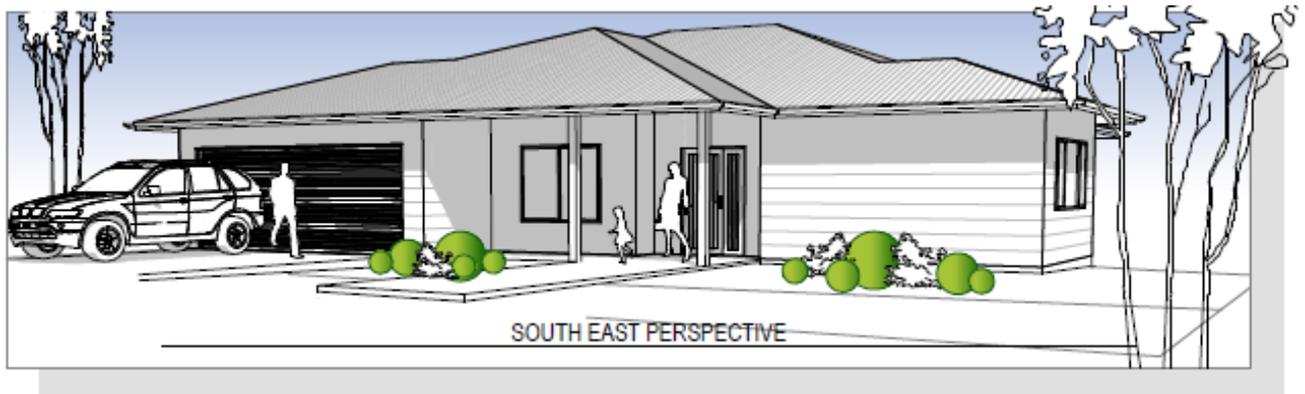
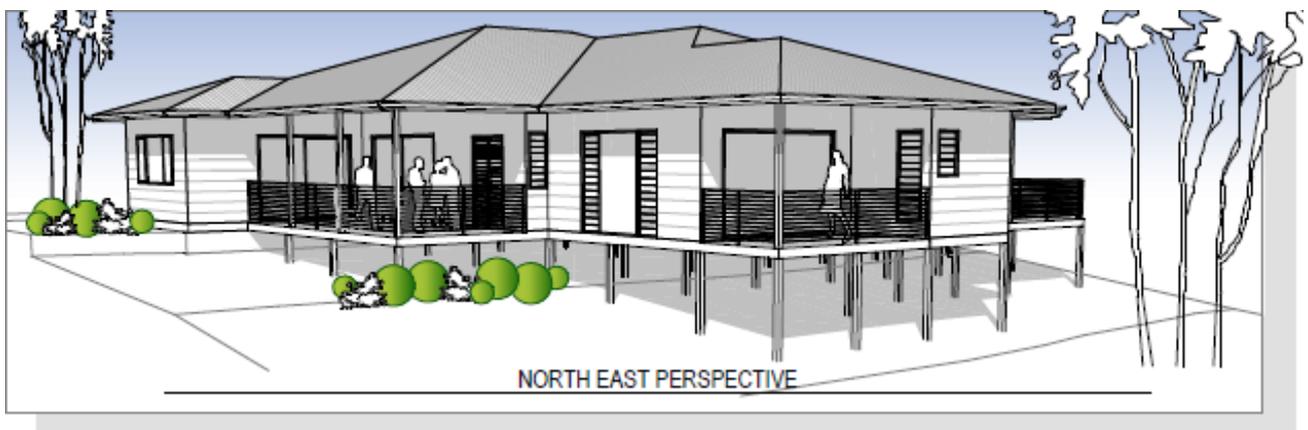


Figure 1b: Rear of case study house



It is recognised that this single-storey design is not suitable for all sites. However, houses built on narrow lots that have two or more storeys or have close neighbouring properties can still use a range of passive design principles, such as those listed in section 2.1.

For each of the four case studies a software assessment was undertaken. This assessment provided a report about the dwelling's predicted heating and cooling loads for the year. These results were then used to identify the most suitable compliance path for the design in the particular climate zone.

4.1 Base house design specifications

The following items were used for the house's base design specifications:

- elevated suspended timber floor to the majority of the house, underneath is unenclosed with no floor insulation
- remaining floor area is concrete slab-on-ground to the garage, office and entry. Depending on location, it may also include either the living room or bedroom
- inclusion of at least one outdoor living area that complies with the minimum QDC requirements to achieve 1/2-star credit e.g. covered area of minimum 12 square metres,

insulation with an R-value of R-1.5 for downward heat flow (refer to Appendix 3 for further detail on insulation). A compliant ceiling fan (½-star credit) was not included

- ceramic tiles to office, living room and wet areas (bathrooms/ensuites, toilets and laundry)
- carpet and underlay in bedrooms, timber flooring elsewhere
- concrete floor in garage
- 70 millimetres timber stud wall framing and weatherboard cladding, with reflective foil insulation providing a total of R-1.0 to external walls
- hip roof with steel sheeting, reflective foil insulation under sheeting (ventilated ceiling space via eave vents and roof vent)
- plasterboard ceilings, 2400 millimetres ceiling height, R-2.0 bulk insulation (batts to ceiling)
- light colours to the roof and external walls
- a mix of louvres and sliding windows appropriately specified and located to promote natural airflow. Sliding aluminium-framed windows are single clear pane (3 millimetres glass)
- eaves with a minimum width of 600 millimetres.

Some of the base house design specifications, including insulation and windows, may have been modified to achieve compliance with the 6-star housing requirement given the particular climate zone. Any changes are noted in each of the case studies. More information on insulation and windows can be found in Appendix 3.

It is important to note that case studies are assessed as stand-alone examples which focus on energy efficient design. They do not consider other matters, such as the proximity and influence of neighbouring buildings and all potential amenity issues, such as crime prevention through environmental design (CPTED).

Critically, the case studies presented are specific for each site and climate zone. They have used the ideal orientation and aspect (north facing and falling to the backyard) to optimise energy efficiency and comfort level. If orientation and aspect were simply rotated to a different position, then the case studies would not have complied. For example, if the living rooms were facing west, then the design would not have achieved 6 stars.

5 Case studies

Four case study designs assessed in each of Queensland’s climate zones have been used to identify suitable design strategies. A cost-effective compliance option for each zone is presented below.

5.1 Climate zone 1—Tropical (Townsville)

Townsville is located in Building Code of Australia’s climate zone 1 which covers Australia’s tropical areas. This zone is characterised by hot humid summers, warm winters and high summer rainfall. The design’s main aim is to cool the interior of the home all year round. The house design used for Townsville is presented in Figure 2.

Figure 2: Case study deck plan for Townsville



Compliance option chosen

- **Software only** (6 stars)
- The software report indicated that the base house design achieved above satisfactory results for cooling during summer and for heating during winter.

Design changes required

- For Townsville, no changes were required to the base house design and specifications to achieve 6-star compliance.

Design consideration—climate zone 1

When designing for energy efficiency in this zone it is important to protect key living areas from the heat of the sun, to use lightweight construction material which can cool quickly after the sun sets and to promote good airflow throughout the home. This can be achieved using the following design principles:

- orientating the house and configuring rooms to minimise direct sunlight and capture the prevailing breezes
- allowing the breeze to flow over and under the building shell to assist in cooling
- carefully locating wall openings to allow breezes to flow through the interior, including having internal openings to ensure cross-ventilation is promoted
- considering the use of openings higher in the wall or in a clerestory to allow rising hot air to escape and to promote natural air movement; higher ceilings (2700 millimetres instead of 2400 millimetres) could also assist to remove warm air from the room's floor
- providing adequate shading of all walls, especially over windows to minimise heat entering the building
- using light colours on the roof and external walls so that as little heat as possible is absorbed into the material.

Some designers set aside a space within the home as a conditioned space in which an energy efficient air-conditioner can be installed and used when extremely hot and humid conditions occur during summer. With this design, the living room could be air-conditioned and would be well-sealed (including the addition of a door to the foyer) and heavily insulated (including the internal walls). Treated glazing, such as low-e or tinted glass, would be needed in this room to reduce the heat load from direct summer sun. This would allow the room to be fully closed and air-conditioned in extremely hot conditions during summer, and open and free-flowing during cooler periods.

Designer's toolbox—climate zone 1

In this climate zone the focus is on cooling the home all year round.

Orientation and room zoning

- Townsville's prevailing cool breezes come from the north-east, especially in summer. This design has located the main living areas (including the outdoor living area) and bedroom 1 to capture these breezes.
- In mid-summer, the south-eastern (morning) and south-western (afternoon) walls will be subject to direct heating from the sun. For this design, the garage is positioned to take the afternoon sun and the living room (mainly used in the evenings) has been located to capture the morning sun.
- In mid-winter, the north-eastern to north-western walls will be subject to the sun.

Natural airflow and cross-ventilation

- Appropriate openings should be located to allow cooling breezes into the home. This design will use a combination of doors, louvre windows and other open able windows along the north and east facing rooms.
- Internal openings should be located to enhance airflow throughout the home. Consider using timber blade Louvre windows or Louvre doors to improve airflow between rooms.
- Include ceiling fans to promote internal air movement during warmer conditions.

Shading

- Eaves are essential for houses in Townsville's climate, and combined with appropriately located outdoor living areas assist in shading main windows and exposed walls. Eaves work well in Townsville where the summer sun is at a higher angle.
- Where possible, suitable landscaping to assist with shading can also provide some benefit. For this design, the use of a tree to shade the living room would be considered.

Insulation and material choices

- Insulation is important, particularly in the ceiling to provide a barrier between the roof space and the interior of the home.
- Lightweight construction can be used where building materials are subject to direct sunlight as it is more responsive to changes in temperature.
- Thermal mass can be used where it can be cooled or can be maintained for a more stable temperature via connection to the ground.
- Lighter colours tend to reflect rather than absorb heat, therefore light coloured materials do not become as hot and can cool down more quickly than darker colours.

5.2 Climate zone 2—Subtropical (Sunshine Coast)

Sunshine Coast is located within Building Code of Australia's climate zone 2 which covers Australia's sub-tropical areas. This zone is characterised by warm humid summers and mild winters. The design's main aim is to cool the interior of the home for summer, and provide some warmth for winter. This house has been designed for a location near the coastline to take advantage of views. The house design used for the Sunshine Coast is presented in Figure 3.

Figure 3: Case study plan for Sunshine Coast



Compliance option chosen

- **Elemental (BCA 2009) plus QDC optional credits** (5 stars + 1 star for outdoor living area with ceiling fan).
- The software report indicated that the base design achieved satisfactory results for cooling during summer. It did not achieve satisfactory results for heating during winter. The design was adjusted to improve solar access to the kitchen/family room and bedroom 1.
- The outdoor living area was changed to allow morning winter sun through the kitchen window.
- This option provided compliance at a lower cost than software, maintained the design's integrity, had minimal impact on the local natural environment, provided good natural light and ventilation and would not reduce the occupant's access to coastal views.

Design changes required

- For the Sunshine Coast, the following design and specification changes were required to achieve 6-star compliance:
 - alter the layout of the eastern outdoor living area and include a ceiling fan (additional ½-star credit)
 - adjust the northern, eastern and western eaves and shading to allow sun access during winter (while maintaining summer shading)
 - increase the roof/ceiling insulation to achieve a total value of R-2.7 (refer to Appendix 3 for further detail on insulation)
 - increase the wall insulation to achieve a total value of R-1.9
 - change to a medium colour roof.

Design considerations—climate zone 2

Local climatic conditions can vary considerably across this zone and need to be specifically factored into the design for energy efficiency. For example, coastal areas can have different prevailing conditions to hinterland areas.

Across the zone it is important to control the sun through good orientation and shading considerations.

For this design, lifestyle issues were also considered within the context of the home's location, especially the eastern location of the outdoor living area. Designers will want to provide a bright open holiday style interior, provide views to the coast and capture the cooling sea breezes in summer.

Designer's toolbox—climate zone 2

In this climate zone the focus is on keeping the home cool in summer and introducing some warmth in winter.

Orientation and room zoning

- Sunshine Coast experiences cooling sea breezes which, depending on the time of year, vary from north east, east and south east. This design has located the main living areas (including the outdoor living area) and bedroom 1 to capture these breezes.
- In mid-summer, the eastern (morning) and western (afternoon) walls will be subject to direct heating from the sun.
- In mid-winter, the north eastern, northern, and north western walls will be subject to the sun.

Natural airflow and cross-ventilation

- Appropriate openings should be located to allow cooling breezes into the home. This design will use a combination of doors, louvre windows and other openable windows along the north and east facing rooms.
- Internal openings should be located to enhance airflow throughout the home. Consider using timber blade louvre windows or louvre doors to improve airflow between rooms.
- Ceiling fans should be included to promote internal air movement in warmer conditions.

Shading

- Eaves are essential for houses on the Sunshine Coast, except where specifically reduced or omitted to provide solar access.
- An appropriately located and covered outdoor living area can assist in shading the main window areas and exposed walls.

Insulation and material choices

- Insulation is important, particularly in the ceiling to provide a barrier between the roof space and the interior of the home.
- Lightweight construction can be used where building materials are subject to direct sunlight as it more responsive to changes in temperature, and is useful in places like Sunshine Coast where temperature is relatively mild.
- Thermal mass can be used where it can be cooled or can be maintained for a more stable temperature via connection to the ground.
- Colours on external materials should be carefully chosen for specific locations to make best use of the material's reflection or absorption properties.

5.3 Climate zone 3—Hot arid (Charleville)

Charleville is located in Building Code of Australia's climate zone 3 which covers Australia's arid interior. This zone is characterised by hot dry summers and cold winters. This variability presents some complex design issues to be considered. The design's aim is to provide access to the sun for internal warmth in winter and prevent heat loss through the building shell. There also is a need to prevent heat gain during summer.

Much of climate zone 3 has a relatively flat topography, which generally lends itself to a level building site. These areas are also characterised by highly reactive soils and flood-prone land. Depending on the location of the site, slab-on-ground construction may not be appropriate. The house design used for Charleville is presented in Figure 4.

Figure 4: Case study plan for Charleville



Compliance option chosen

- **Elemental (BCA 2009) plus QDC optional credits** (5 stars + 1 star for outdoor living area with ceiling fan).
- The software report indicated that the base design failed to achieve satisfactory results for cooling during summer or for heating during winter. The report indicated that improved shading from wider eaves would assist in summer and revealed that the design would benefit by re-locating some of the living spaces (living and family rooms) to better capture the northern winter sun. The new layout allows access to the morning and early afternoon winter sun into the open living area, uses the afternoon sun to warm some of the bedroom spaces and uses the garage to provide some protection from the westerly winter winds.
- This option provided compliance at a lower cost than software only, maintained the design's integrity, had minimal impact on the local natural environment and provided good natural light and ventilation.

Design changes required

- For Charleville, the following design and specification changes were made to achieve 6-star compliance:
 - fully elevated and enclosed lower storey (given flat topography and flood-prone area)
 - increase the roof/ceiling insulation to a total value of R-2.7
 - increase the wall insulation to a total value of R-1.9
 - increase the roof eaves to 900 millimetres
 - include a ceiling fan with the outdoor living area (½ star)
 - change glazing to northern windows to low-e glazing (refer to Appendix 3 for further detail on windows).

Climate design considerations—climate zone 3

When designing for energy efficiency in this zone, a mix of cooling for hot summers and heating for cold winter evenings is needed.

Shading devices are important and need to be carefully designed to prevent too much solar access during summer but allow enough into the interior during winter. The summer sun in this climate zone is high in the sky for most of the day. Wider eaves at 900 millimetres have been added to shade all walls as much as possible in summer. Conversely, during winter the sun is much lower in the sky on the northern face and the design needs to permit solar access during winter.

Windows need to be carefully designed for orientation, window size and glazing type. The BCA glazing calculator allows the designer to adjust the U-value and solar heat gain coefficient using values provided by manufacturers (refer to Appendix 3 for further detail on windows). A window system that provides a thermal break (between the inside and outside of

a window frame) may also need to be used to improve the overall thermal performance of the window system.

For sites that can include thermal mass, the ground under a home remains at a fairly constant temperature and can provide a moderating influence on the extremes of air temperature if suitable contact with the foundation can be achieved. In these cases, the thermal mass that is exposed to winter sun can be used to absorb heat and slowly release warmth into the room during the evening. In summer, it can draw cooling from the ground connection and release it into the room.

Designer's toolbox—climate zone 3

In this climate zone the focus is on keeping the home cool in summer and warm in winter.

Orientation and room zoning

- Charleville experiences summer breezes from the east and north-east. This design has located the main living areas (including the outdoor living area) and bedroom 1 to capture these breezes.
- In winter, the cold winds are predominantly south-easterly. The design needs to balance protecting spaces from winter winds and allowing summer breeze into the home.
- In mid-summer, the eastern (morning) and western (afternoon) walls will be subject to direct heating from the sun.
- In mid-winter, the eastern, northern, and western walls will be subject to direct sunlight. The design was adjusted to improve solar access to the living areas during the day, bedroom 1 in the morning and other bedrooms in the afternoon.

Natural airflow and cross-ventilation

- Appropriate openings should be located to allow cooling summer breezes into the home. This design will use a combination of doors, Louvre windows and other open able windows along the east facing rooms.
- Well-designed openings high in the wall can promote natural airflow on hot still days as hot air rises. Higher ceilings (2700 millimetres instead of 2400 millimetres) could also assist in removing warm air from the room's floor.
- Provisions should be made for the home to be closed-up on the breeze-facing side when the summer breezes become too hot. Ceiling fans are important to circulate air internally during these times.
- A ceiling fan included on the outdoor living area can encourage occupants to use the deck during hot periods.
- Internal openings should be located to enhance airflow throughout the home. Use of timber blade louvre windows or louvre doors can be considered to improve airflow between rooms.
- Openings need to be well-sealed when closed so heat or cold drafts cannot enter the room.

- The window sizes may be smaller in some parts of the home and treated glazing, such as low-e or tinted glass, will be required in key areas.
- Consideration can be given to specifying suitable landscaping, including (where practical), a water feature, such as a pond or pool, to the east or north to naturally cool the summer breeze before it enters the home.

Shading

- Wider eaves are designed to protect the home from the summer sun, and still access the lower angle winter sun to warm the interior.
- An appropriately located and covered outdoor living area can assist in shading the main window areas and exposed walls.

Insulation and material choices

- Insulation is important, particularly in the ceiling to provide a barrier between the roof space and the interior of the home.
- Depending on the location, slab-on-ground can be used to moderate temperature extremes. However consideration can also be given to other design solutions where cut and fill is required or sites with highly reactive soils or locations exposed to flooding.
- Thermal mass can be used to maintain a warmer temperature during winter nights where it can be located to absorb heat from the winter sun during the day but only where it is well shaded during summer.
- Lightweight construction is more responsive to changes in temperature and while it will warm up quickly on a winter morning, it will also cool down quickly at night in summer.
- Colours of external materials should be carefully chosen for specific locations to make best use of the material's reflection or absorption properties. Use of darker colours should only be used where walls are well-shaded and can be cooled by landscaping features, such as ponds, in association with summer breezes.

5.4 Climate zone 5–Warm temperate (Toowoomba)

Toowoomba is located in Building Code of Australia’s climate zone 5 which covers warm temperate areas. This zone is characterised by cool winters and warm summers. The design’s main aim is keep the home warm in winter. The house design used for Toowoomba is presented in Figure 5.

Figure 5: Case study plan for Toowoomba



Compliance option chosen

- **Elemental (BCA 2010) only** (6 stars).
- The software report indicated that the base house design achieved satisfactory results for cooling during summer; however it did not achieve satisfactory results for heating during winter. A more detailed examination of the report revealed that the design would benefit by re-locating some of the living spaces (living and family rooms) to better capture the northern winter sun access. The new layout allows the morning and early afternoon winter sun into the open living area, uses the afternoon sun to warm some of the bedroom spaces and uses the garage to provide some protection from the westerly winter winds.
- This option provided compliance at a lower cost than software, maintained the design's integrity, had minimal impact on the local natural environment, and provided good natural light and ventilation.

Design changes required

- For Toowoomba, the following design and specification changes were made to achieve 6-star compliance:
 - increase the roof/ceiling insulation to achieve a total value of R-4.1
 - increase the wall insulation to achieve a total value of R-2.8
 - add floor insulation to a total value of R-1.0 (downwards)
 - adjust the glazing for compliance against the BCA calculator. Some windows were upgraded using low-e glazing. In selecting the window options, consideration was given to promoting solar access in some areas.

Design considerations—climate zone 5

When designing for energy efficiency in this zone, the important principle is to allow the home to warm up when warmth from the sun is available and to ensure that the warmth is retained inside at other times.

In specifying the floor insulation, it is important to choose a material which allows the insulated space to breathe so that condensation cannot form within the space (which over time may cause structural damage).

Windows needs to be carefully designed for orientation, size and type. The BCA glazing calculator allows the designer to adjust the U-value and solar heat gain co-efficient (see Appendix 3) using values provided by manufacturers.

Designer's toolbox—climate zone 5

In this climate zone the focus is on keeping the home warm in winter.

Orientation and room zoning

- Toowoomba experiences summer breezes from the east and south-east. This design has located the main living areas (including the outdoor living area) and bedroom one to capture these breezes.
- In winter, the cold winds are predominantly south-westerly and the garage was located here to provide some protection.
- In mid-summer, the eastern (morning) and western (afternoon) walls will be subject to direct heating from the sun.
- In mid-winter, the eastern, northern and western walls will be subject to direct sunlight. The design was adjusted to improve solar access to the living areas during the day, bedroom one in the morning and other bedrooms in the afternoon.

Natural airflow and cross-ventilation

- Appropriate openings should be located to allow cooling summer breezes into the home. This design will use a combination of doors, louvre windows and other openable windows along the east facing rooms.
- Internal openings should be located to enhance airflow throughout the home. Use of timber blade louvre windows or louvre doors can be considered to improve airflow between rooms.
- Ceiling fans should be included to promote internal air movement during warmer conditions.
- Openings need to be well-sealed when closed so cold drafts cannot enter the room.
- The window sizes may be smaller in some parts of the home and treated glazing, such as low-e or tinted glass, will be required in key areas.

Shading

- Eaves are designed to protect the home from the summer sun, and give access to the lower angle winter sun to warm the interior.
- An appropriately located and covered outdoor living area can assist in shading the main window areas and exposed walls.

Insulation and material choices

- Insulation is important, particularly in the ceiling to provide a barrier between the roof space and the interior of the home.
- Thermal mass can be used to maintain a warmer temperature during winter nights where it can be located to absorb heat from the winter sun during the day.
- Lightweight construction is more responsive to changes in temperature and while it will warm up quickly on a winter morning, it will also cool down quickly at night in summer.
- Colours on external materials should be carefully chosen for specific locations to make best use of the material's reflection or absorption properties.

6 Summary

The Queensland Development Code provides a range of flexible compliance methods and design options. The most cost-effective compliance option for a house to achieve 6-star energy equivalence will depend on its specific design and location. Designers therefore need to consider which would be the most appropriate for each design in its particular location.

The over-riding principle for achieving a 6-star energy equivalence house is that good passive design features are the key to successful compliance. House orientation, room configuration, shading, insulation, natural ventilation and sealing, building materials and external colours all work together to create a more comfortable dwelling for the occupants and can provide ongoing energy savings over the life of the home.

Queensland's range of climate zones requires different design strategies for different areas. In all climate zones, it is important to undertake a site analysis and design homes specifically for local climatic conditions i.e. micro-climate factors such as topography, solar access (including sun paths), adjacent shading and local climatic data (average monthly temperatures, humidity, rainfall, wind speed/direction).

Proper integration of the range of passive design features directly influences the house's energy efficiency and comfort level. No single feature alone can maximise the home's overall performance and different building features can significantly affect the performance of others.

The prevailing climate means that outdoor living areas can enhance the Queensland lifestyle, as well as reduce the need for artificially cooling or heating inside the home.

It is important to note that the software assessment method can provide valuable information on the proposed design through a performance report. This includes identifying whether predicted annual heating or cooling loads could be a problem in the design, via a room-by-room breakdown that can identify poorly performing spaces. These can subsequently be improved by adapting the design.

The base house was designed to allow the principles of universal housing to be incorporated which can allow the dwelling to meet the changing access needs of the occupants across their lifetime. The design provides access to the dwelling from the garage, has no steps and wider than standard hallways. It also has at least one accessible bedroom (bedroom 1) and a bathroom where there is provision for built-in grab rails to be added in the future.

Glossary

BCA	Building Code of Australia (Volume Two)
Clerestory	an elevated window either fixed or openable (e.g. louvres) that is located between the roof and the ceiling. A clerestory is often used with skillion roofs
Climate zone	means an area defined by the Building Code of Australia for specific locations, having energy efficiency provisions based on a range of similar climatic characteristics (refer to Appendix 1 for locations)
Lightweight construction	lighter building materials, such as timber, weather-board products and steel, that do not retain heat and can assist with providing a cooler internal temperature
NatHERS	Nationwide House Energy Rating Scheme which provides information on accredited software rating tools for house energy assessments
QDC	Queensland Development Code MP 4.1—Sustainable buildings
Thermal mass	denser building materials, such as concrete, blockwork, bricks, tiles and other masonry, that can be used to absorb, store and re-release the sun's heat so that it can be slowly released later to create a warmer internal temperature

For further information

Regulatory

Queensland Development Code

All parts of the Queensland Development Code are available on the Department of Local Government and Planning's website at www.dlgp.qld.gov.au

Building Code of Australia

The Australian Building Codes Board includes information on the energy efficiency requirements for residential dwellings at www.abcb.gov.au

Nationwide House Energy Rating Scheme (NatHERS)

Provides information on accredited software rating tools for house energy assessments at www.nathers.gov.au

Australian Standards

Provides access to Australian Standards relevant to building codes at www.saiglobal.com

Useful websites

Building designers

Building Designers Association of Queensland at www.bdaq.com.au

Architects

Australian Institute of Architects at www.architecture.com.au

Building certifiers

Australian Institute of Building Surveyors at www.aibs.com.au

Royal Institution of Chartered Surveyors at www.rics.org/oceania

Accredited house energy assessors

www.absa.net.au

Bureau of Meteorology

Provides historic monthly averages for local climatic data (temperature, humidity, rainfall, wind speed/direction) at www.bom.gov.au

Glazing calculator

Provides calculations to assist with glazing requirements at www.abcb.gov.au

Windows

Provides a list of windows rated for their energy performance at www.wers.net

Insulation handbook

Provides details on thermal performance calculations for typical building applications at www.icanz.org.au/handbook

Your Home Technical Manual

Provides details about specific passive design features at www.yourhome.gov.au/technical

Your Home Renovators Guide

Provides details about renovating an existing dwelling to improve its sustainable design at www.yourhome.gov.au/renovatorsguide

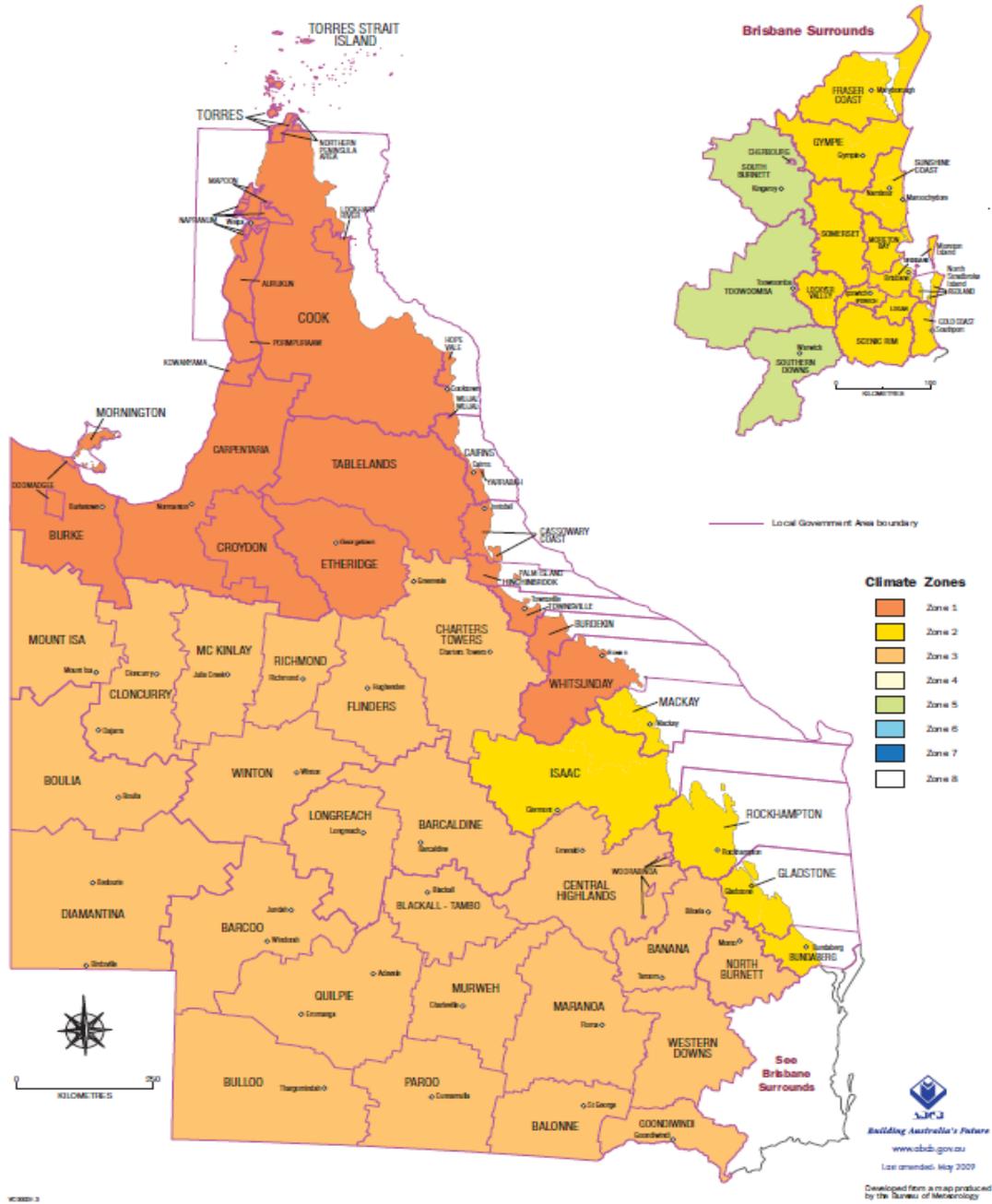
Sun paths

Provides sun path diagrams for a range of Queensland locations at www.works.qld.gov.au

Designing for Queensland's climate

Provides information on concepts of smart and sustainable housing design suitable for Queensland's climate zones at www.works.qld.gov.au

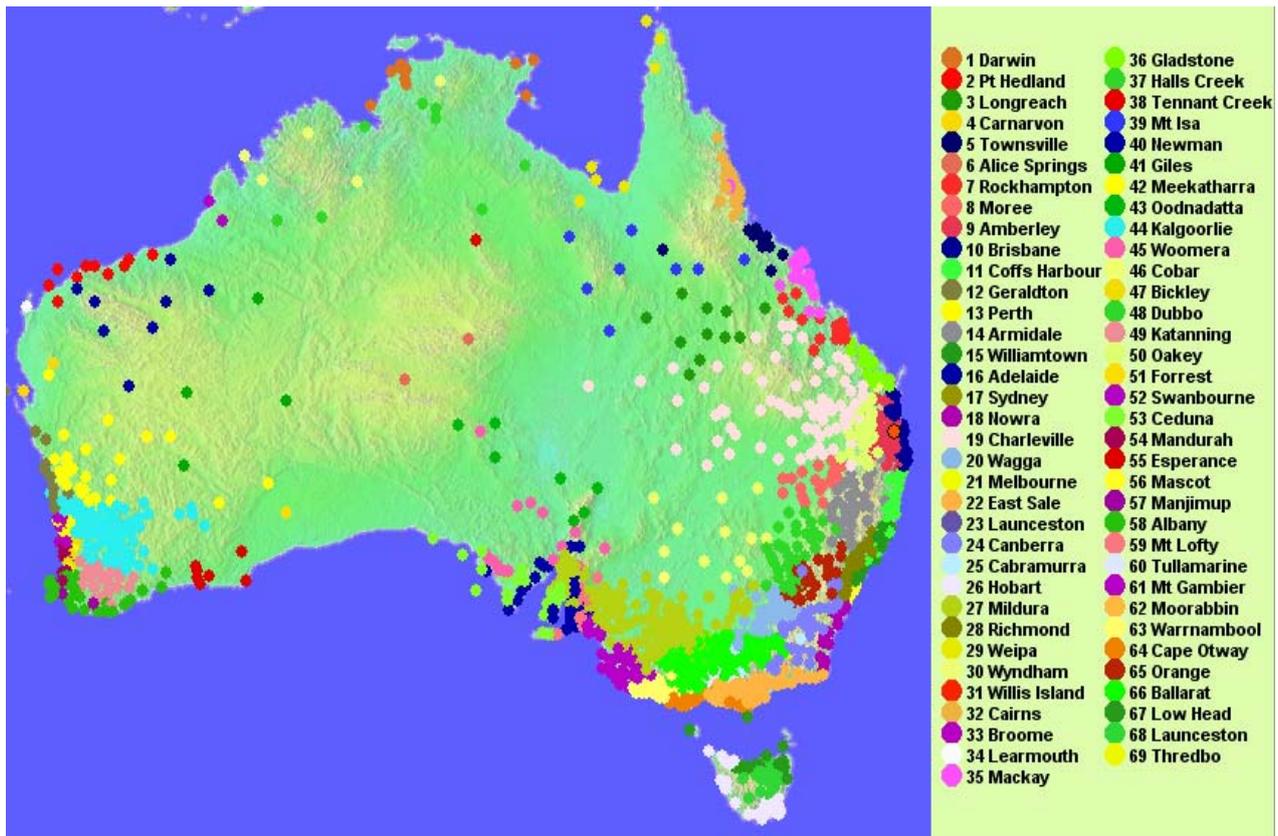
Appendix 1—Building Code of Australia’s climate zones



Zone 1—Tropical	High humidity summer, warm winter
Zone 2—Sub-tropical	Warm humid summer, mild winter
Zone 3—Hot arid	Hot dry summer, warm winter
Zone 5—Warm temperate	Warm summer, cool winter

NB. Zone 4 does not exist in Queensland.

Appendix 2—Software (NatHERS) climate files



Queensland climate files	
Number	Location
3	Longreach
5	Townsville
7	Rockhampton
9	Amberley
10	Brisbane
19	Charleville
29	Weipa
32	Cairns
35	Mackay
36	Gladstone
39	Mount Isa
50	Oakey
	Atherton (proposed)
	Maleny (proposed)
	Toowoomba (proposed)

Appendix 3—Insulation and windows

Insulation

Insulation installed in the roof space and external walls of a dwelling is a key design feature that can be used to assist in achieving energy efficient buildings and thermal comfort. It can reduce the heat and cold transfer between the dwelling and external elements, thereby providing a more stable internal temperature.

Insulation can easily be incorporated into the building fabric for most types of housing constructed in Queensland. The amount of insulation required for a dwelling will depend on the prevailing climatic conditions and its particular design.

Insulation is measured by an R-value, which describes the thermal resistance of a material (i.e. how much it inhibits heat transfer). The higher the R-value number the more effective the insulation will potentially be. The R-value may be measured in one of two ways:

- (1) **System R-value (or Total R-value)**—the total thermal resistance for the sum of all the building materials as well as the insulation product, i.e. building materials + air-films + air spaces + insulation product, or
- (2) **Product R-value (or Material R-value)**—the thermal resistance of the insulation product alone.

It is recommended that any comparisons use the same type of R-value measure.

Installers of insulation must comply with current Queensland safety requirements including those set out in the Electrical Safety (Installation of Ceiling Insulation) Notice 2010 made under the *Electrical Safety Act 2002*. This includes banning the use of metal staples and other forms of conductive fasteners with ceiling insulation and compliance with the Wiring Rules (AS/NZS 3000: 2007 (Amdt 1: 2009) Electrical installations, clause 4.5.2.3) for insulation placed near recessed down-lights.

Under the BCA roof or ceiling insulation products must comply with the labelling, testing, quality assurance and other requirements of AS/NZS 4859.1: 2002 Materials for the thermal insulation of buildings—Part 1 General criteria and technical provisions. Some imported insulation products, such as glass-wool batts and laminated foil, may not comply with this standard. Building practitioners are recommended to purchase insulation from reputable sources and check that it complies with these standards by appropriate means, such as:

- requesting a copy of a report by an accredited laboratory showing that it complies with the standard
- checking that labelling or manufacturing supply documentation includes a statement that it complies with the standard
- that the labelling or manufacturing documentation declares the R-value of the product and it meets the specified R-value for the location of the building.

The inclusion of several recessed down-lights in the ceiling can reduce the effectiveness of ceiling insulation. In these cases, an increase in the minimum R-value of the ceiling insulation should be incorporated. If using the element (DTS) method refer to Building Codes of Australia Volume Two for adjustment values.

Where the software assessment method is used building certifiers must ensure that the requirements of section 3.12.0 of the BCA, including the installation of insulation, thermal breaks and building sealing, are incorporated with the building's design. Without thermal breaks the insulation's effectiveness can be reduced by as much as half. Refer to the BCA's Information Handbook – Volume Two, Chapter Five Deemed-to-Satisfy Provisions for further information.

Windows and glazing

The amount of window area potentially exposed to direct sunlight can influence the energy efficiency of the building shell and thermal comfort of the dwelling. It is therefore important to consider the window to floor area ratio in each room, particularly those exposed to the sun's path. This is potentially a major factor in how much heat and cold can be transmitted through the window into the dwelling during particular times of the year.

Three key elements need to be considered with the type of glazing to be used for the window, these being its performance in terms of:

- solar radiation
- insulation
- daylight transmission.

The type of window (e.g. sliding, casement, hopper, sash and louvre), glazing used (e.g. clear glass, treated glazing, such as tinted or low-e, or double-glazing) and its size all influence the energy efficiency potential of the room/dwelling. If treated glazing is used, the degree of daylight able to pass through the window can be affected.

A window system covers both the glazing and window frame. For thermal performance, window systems have two measures:

- (1) **Solar Heat Gain Coefficient (SHGC)**—is a measure of how readily the window system admits solar radiation, i.e. how well it can potentially reduce heat gain from the sun entering the room. It includes both the direct amount of solar radiation transmitted through the glass (as short wave) and the amount absorbed and re-radiated into the dwelling (as long-wave), as shown in Figure 6. The SHGC value is expressed as a number between 0 and 1. Window systems with a lower SHGC have a better solar performance as less solar radiation can be transmitted into the room.
- (2) **Total U-value**—is a measure of the window system's insulation ability (conductance) i.e. how well it can potentially prevent heat from escaping the room. The total U-value is expressed as watts per square metre per degree Celsius ($W/m^2\text{ }^{\circ}C$). A lower total U-

value indicates a better insulator as heat can more easily flow from the warm side to the cool side of the window, as shown in Figure 6. Window systems with a lower total U-value have a better insulation performance as they are able to resist heat flow in and out of the room.

Figure 6: Influence of glazing on heating and cooling

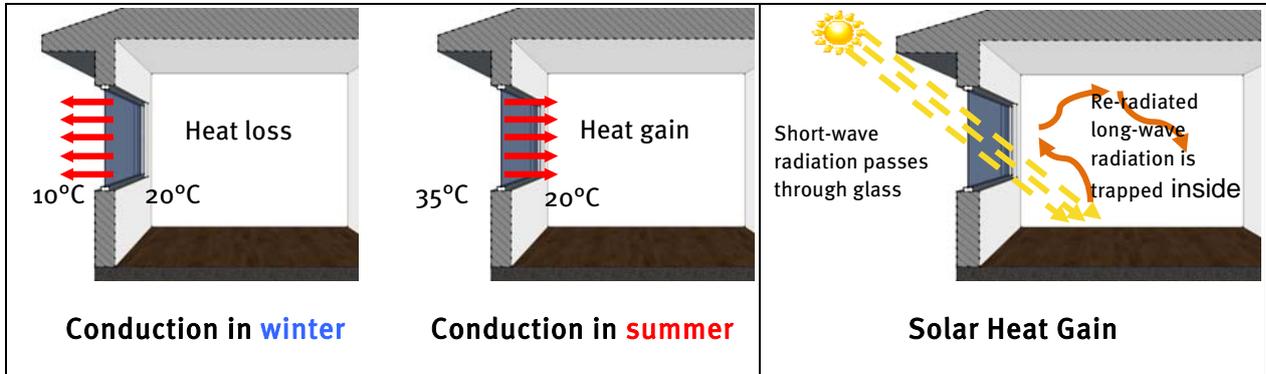


Image supplied courtesy of the Australian Building Codes Board

Window suppliers and manufacturers can provide the rated SHGC and the total U-value for their glazing products.

The window systems required will depend on the prevailing climatic conditions and the dwelling's particular design given the interaction of its orientation and building materials used. Designing window systems for solar radiation (SHGC) is usually the more critical component to reduce heat gain from hot summer sun. The total U-value is generally a more important consideration for dwellings in cooler climates.

The position, types and sizes of windows used, including their glazing and framing, is increasingly becoming a critical element in promoting energy efficient households. This also includes consideration of window awnings and coverings that can provide some shading to the window area (depending on the time of year).

In situations where a property is located within a designated transport noise corridor, glazing (and insulation) can also be a key design feature in complying with the Queensland Development Code MP 4.4–Buildings in a Transport Noise Corridor.



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