

# Thermal performance for timber-framed residential construction



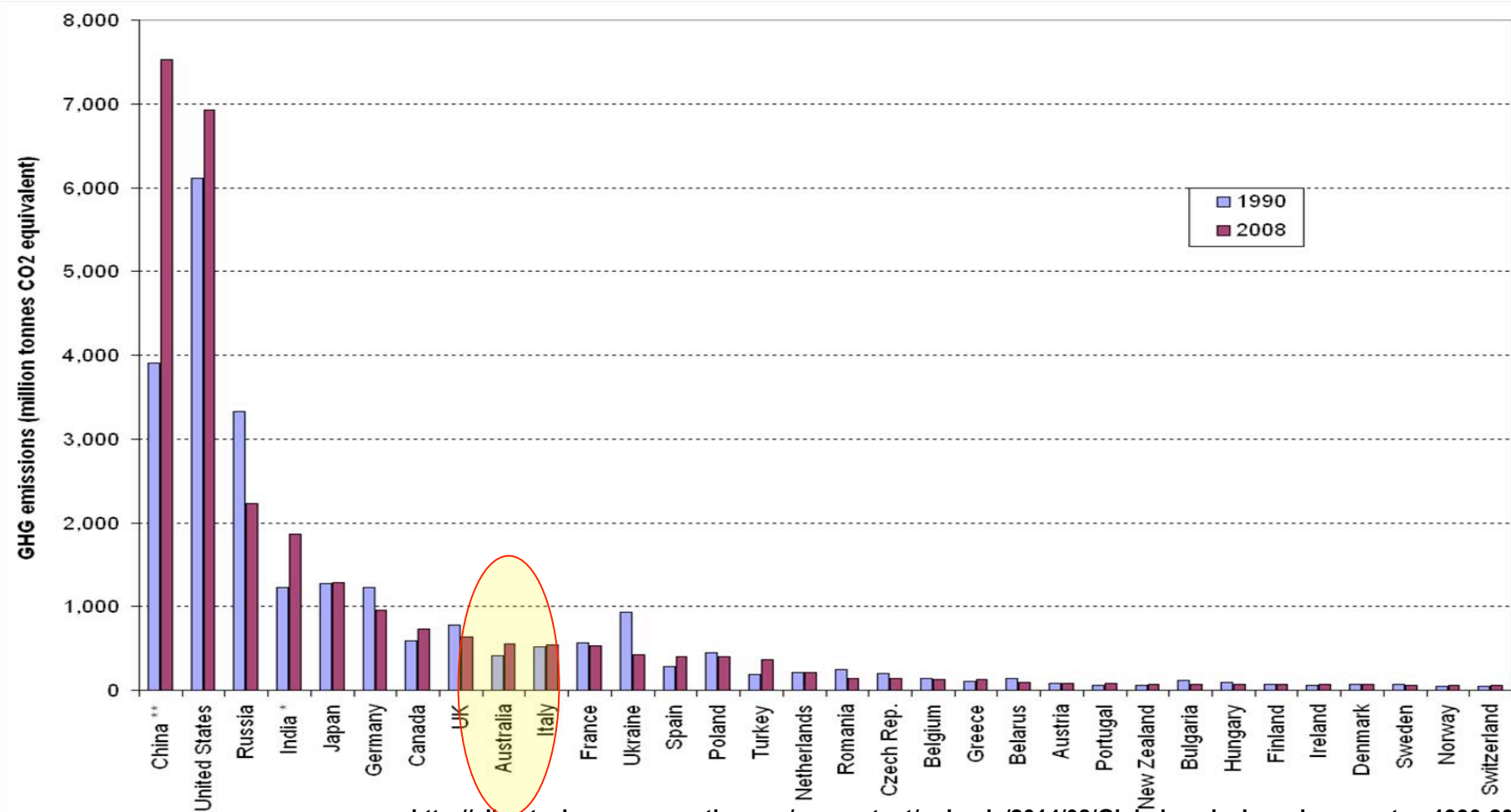
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# Why is Energy Efficiency Important



[http://climatechangeconnection.org/wp-content/uploads/2014/08/Global\\_emissions\\_by\\_country\\_1990-2008.jpg](http://climatechangeconnection.org/wp-content/uploads/2014/08/Global_emissions_by_country_1990-2008.jpg)



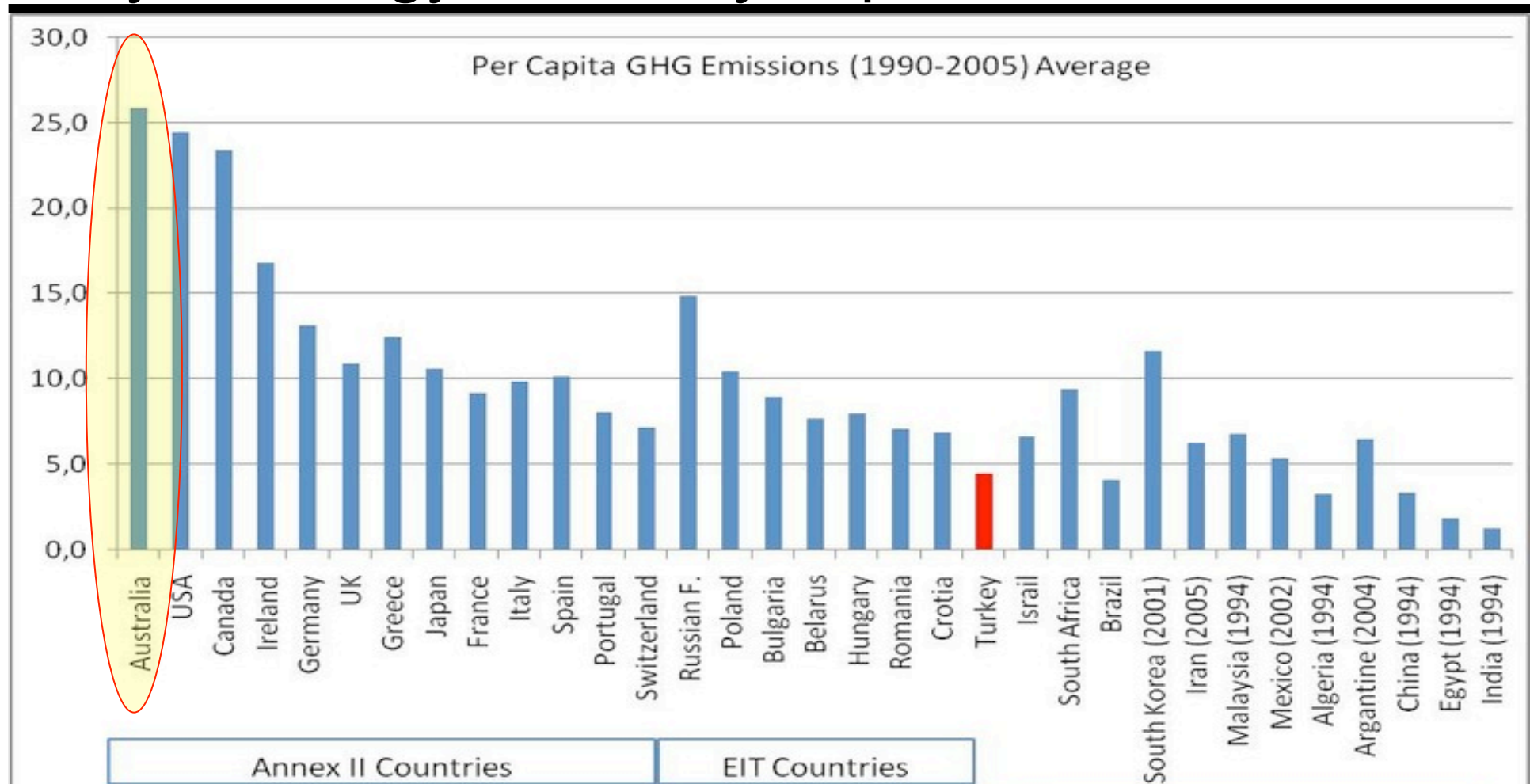
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# Why is Energy Efficiency Important



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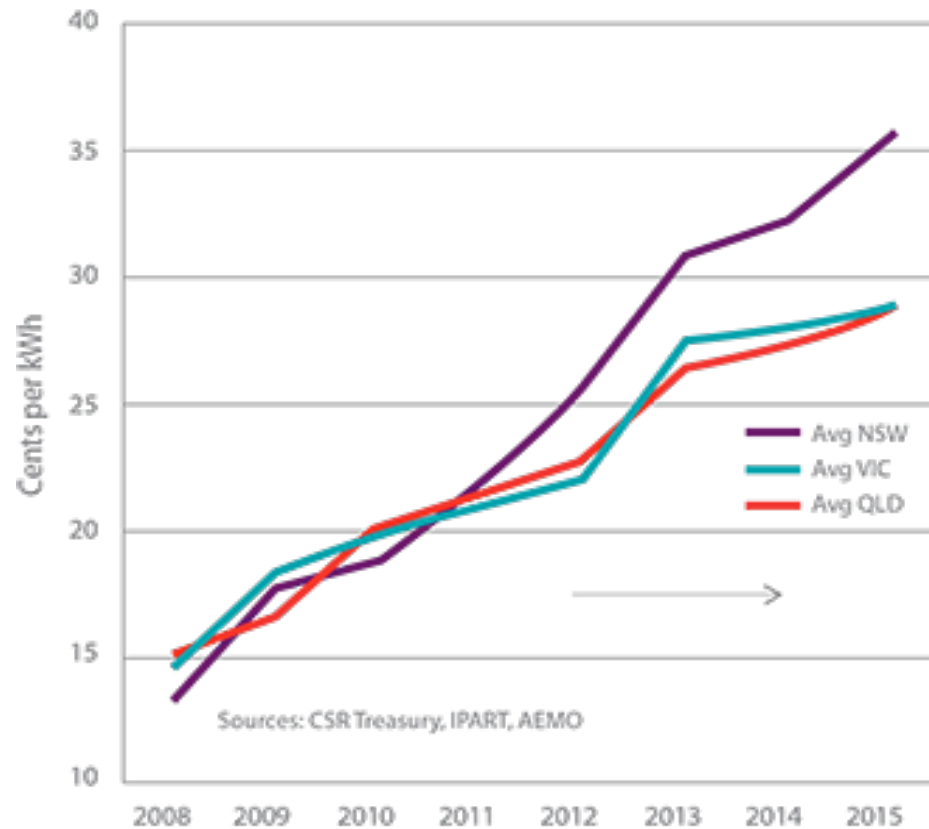


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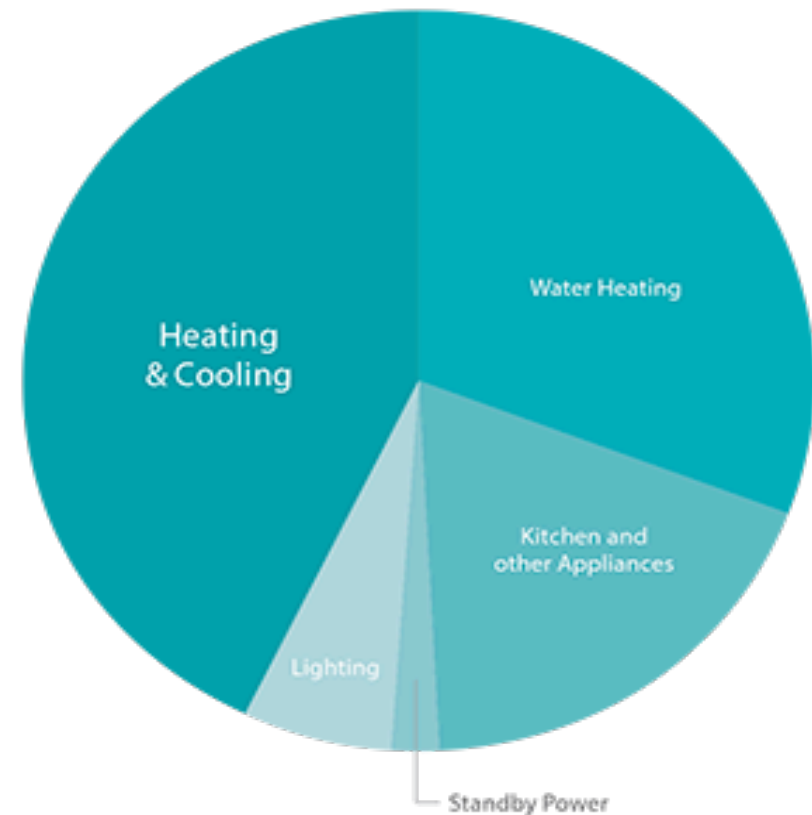
# Why is Energy Efficiency Important

## Average Residential Electricity Tariffs



## Home Energy Use

(Baseline Energy Estimates, 2008) Source: yourhome.gov.au



<http://mysolar.com.au/wp-content/uploads/2014/03/MySolar-Energy-Efficiency-Stats.png>



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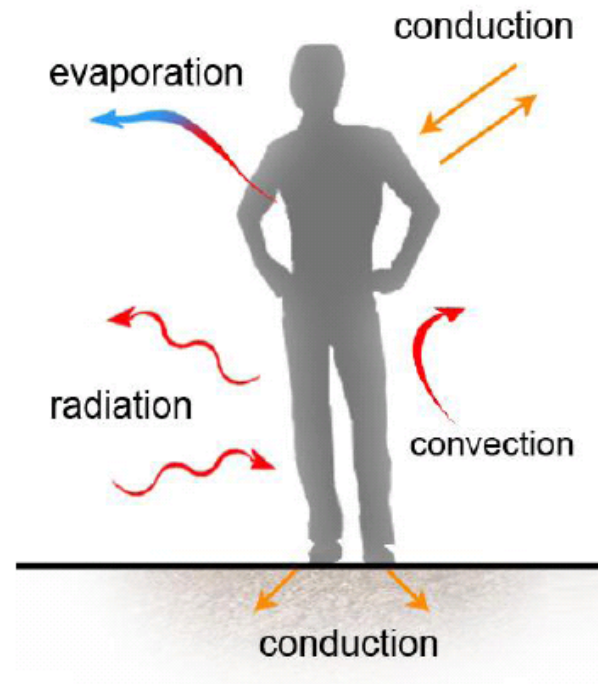


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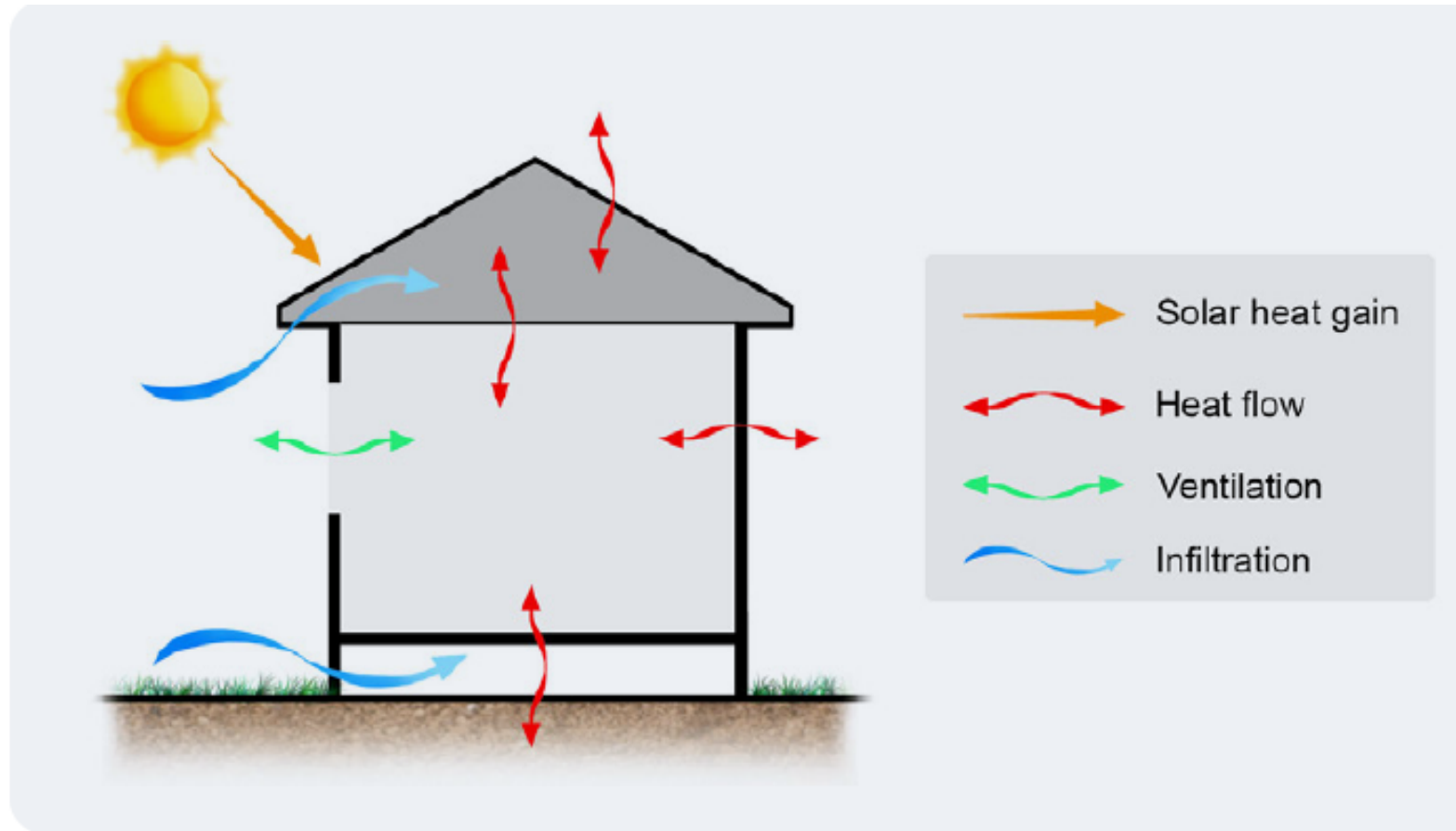


# Thermal Comfort



Air Flow	<div></div>	20%
Air Temperature	<div></div>	20%
Mean Radiant Temperature	<div></div>	60%

# What contributes to thermal performance



**Figure 1: energy flow in a residential building**

# Legislation and Design



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# Legislation and Design

Energy Intensity (Per Square Meter Per Annum)							
Location	5.0 Stars	6.0 Stars	% Improvement	7.0 Stars	% Improvement	8.0 Stars	% Improvement
Broome	335 MJ/m <sup>2</sup>	285 MJ/m <sup>2</sup>	15%	234 MJ/m <sup>2</sup>	18%	182 MJ/m <sup>2</sup>	22%
Brisbane	55 MJ/m <sup>2</sup>	43 MJ/m <sup>2</sup>	22%	34 MJ/m <sup>2</sup>	21%	25 MJ/m <sup>2</sup>	26%
Perth	89 MJ/m <sup>2</sup>	70 MJ/m <sup>2</sup>	21%	52 MJ/m <sup>2</sup>	26%	34 MJ/m <sup>2</sup>	35%
Hobart	202 MJ/m <sup>2</sup>	155 MJ/m <sup>2</sup>	23%	113 MJ/m <sup>2</sup>	27%	71 MJ/m <sup>2</sup>	37%

**Table 1: Energy efficiency improvement per star rating**



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# Legislation and Design

Location of Insulation	R-Value
Sub-floor – Platform floors	Up to R4.0
Sub-floor – Concrete Slab-on-ground	Up to R3.0
Walls	Up to R6.0
Ceiling	Up to R8.0

***Table 8: Potential increased levels of thermal insulation.***



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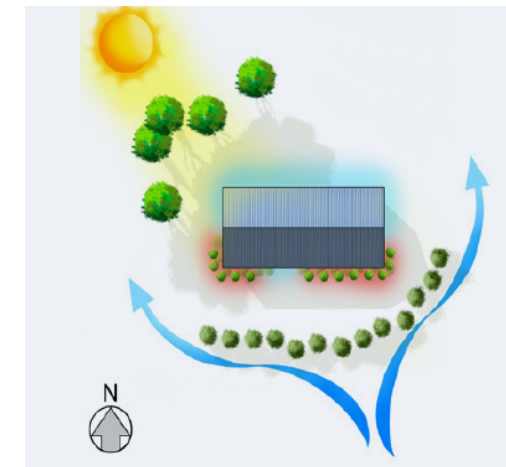
# Guide Style

## 4.2.1 House Location and Orientation

Siting a house is inevitably influenced by the views, and location of street frontages and neighbouring buildings. However, a house's orientation with respect to solar radiation, shading, breezes and room-usage patterns has significant impact on its thermal performance. Research has shown that correct house orientation can save up to 60% of lifetime heating and cooling costs.

### General considerations:

- **Siting** - locate the house to capture available cooling breezes, especially in warmer climates.
- **Layout** - position living spaces where they will benefit from solar heat gain when heating is needed and where solar gain can be minimised when cooling is required.
- **Maximise daylight** - use natural daylight to limit the need for energy-consuming electrical lighting. In some countries, regulations mandate no place within a room is to be more than 6 metres from an opening window.
- **Passive solar heating** - use solar heat for warmth wherever possible.
- **Natural shade** - use natural shade wherever possible and avoid exposure to the afternoon sun.
- **Indoor-outdoor living** - couple living areas with shaded outdoor spaces for summer.
- **Capturing cooling breezes** - allow the capture of breezes to provide an efficient and natural way to cool buildings and occupants in all climates.
- **Eastern morning sun** - use for warmth on cold mornings when appropriate.
- **Northern sun** - control exposure to the northern sun for the best orientation for solar heating.
- **Western afternoon sun** - limit this exposure; it is undesirable in most climate zones.
- **Controlled shade** - carefully design shading to allow warming sun in cooler months while excluding it during warmer months.



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# Guide Style

## Climate specific considerations:

Zones 1 and 2 <i>Hot and humid</i>	Zones 3 and 4 <i>Hot and dry</i>	Zones 5 and 6 <i>Temperate</i>	Zones 7 and 8 <i>Cool temperate and cold climates</i>
<ul style="list-style-type: none"> <li>• <b>Orientation</b> - position the house to make the most of cooling breezes and shade it from unwanted solar radiation.</li> <li>• <b>Breeze</b> - focus on capturing breeze for living spaces in the afternoon and evening.</li> <li>• <b>Western sun</b> - limit exposure to western sunlight. It is difficult to control throughout the year due to its low altitude and overheating of western facades can render the house uncomfortably hot well into the night.</li> <li>• <b>Southern aspect</b> - use the southern aspect to create well-ventilated internal or external spaces on the south side of the building. These can make useful cool refuges.</li> </ul>		<ul style="list-style-type: none"> <li>• <b>Orientation</b> - position the house to promote use of solar passive design principles.</li> <li>• <b>Layout</b> - position living spaces to the north for winter sun.</li> <li>• <b>Cold winds</b> - block cold winds that will generate drafts inside the house. These drafts are a problem for efficient thermal performance in temperate and cool climates. Protection from cold winds by vegetation or built screens is desirable.</li> <li>• <b>Eastern sun</b> - use morning sun to provide warmth and physiological benefits.</li> <li>• <b>Southern aspect</b> - avoid using this aspect for habitable spaces as it generally gets no exposure to sunlight.</li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Eastern sun</b> – give thought to this exposure – early summer sun can cause overheating.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Solar passive design</b> – orientate the house to assist solar passive design principles.</li> <li>• <b>Eastern sun</b> – consider making use of the eastern sun – it may be wanted on winter mornings.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Northern sun</b> – position living spaces to the north but with access to cooling breezes, especially in summer.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Northern sun</b> – position living spaces to the north and spaces likely to be used in the morning to the north or east.</li> <li>• <b>Avoid cold winds</b> – limit exposure to cold winter winds.</li> </ul>



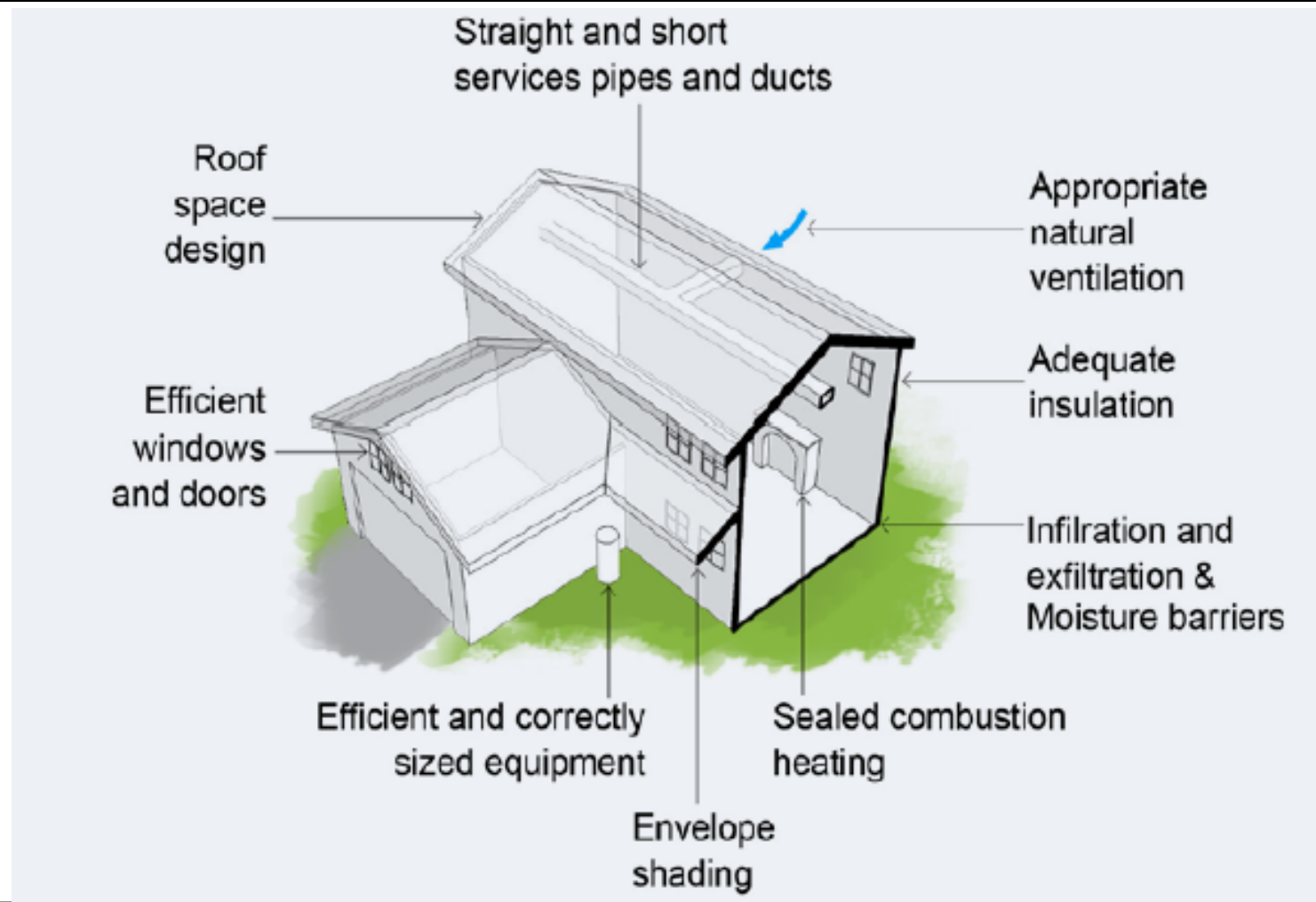
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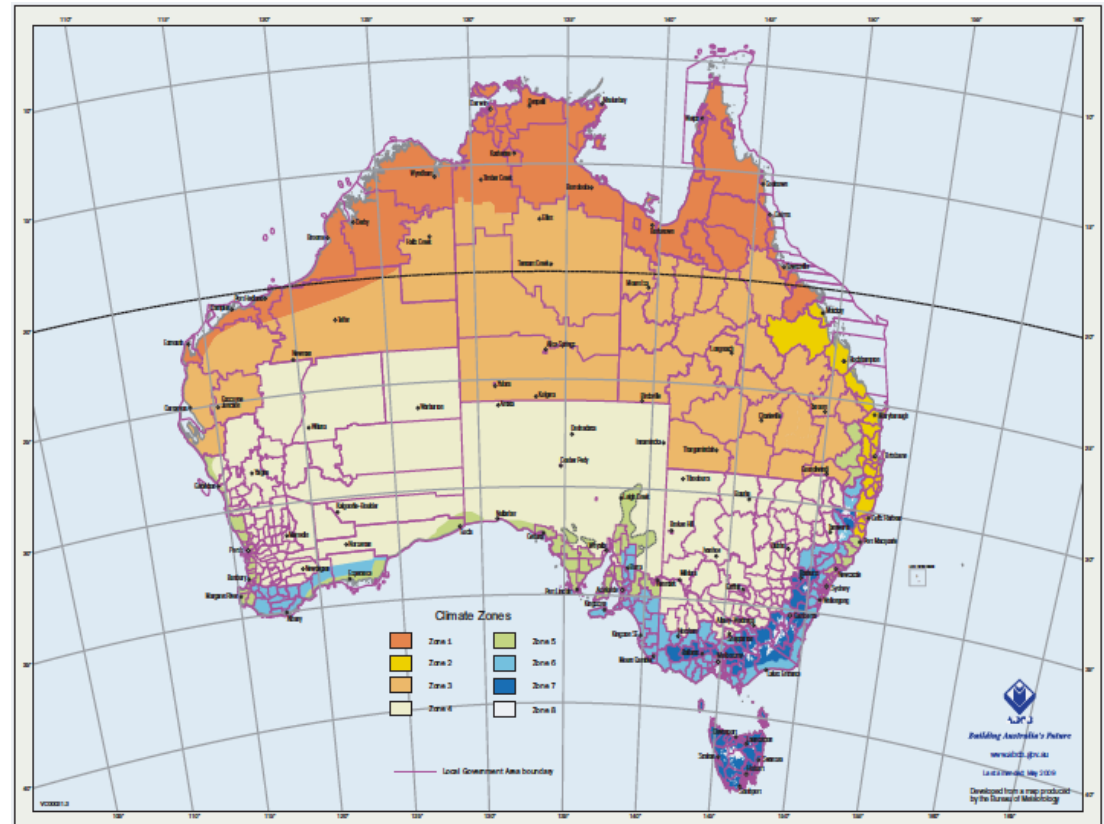
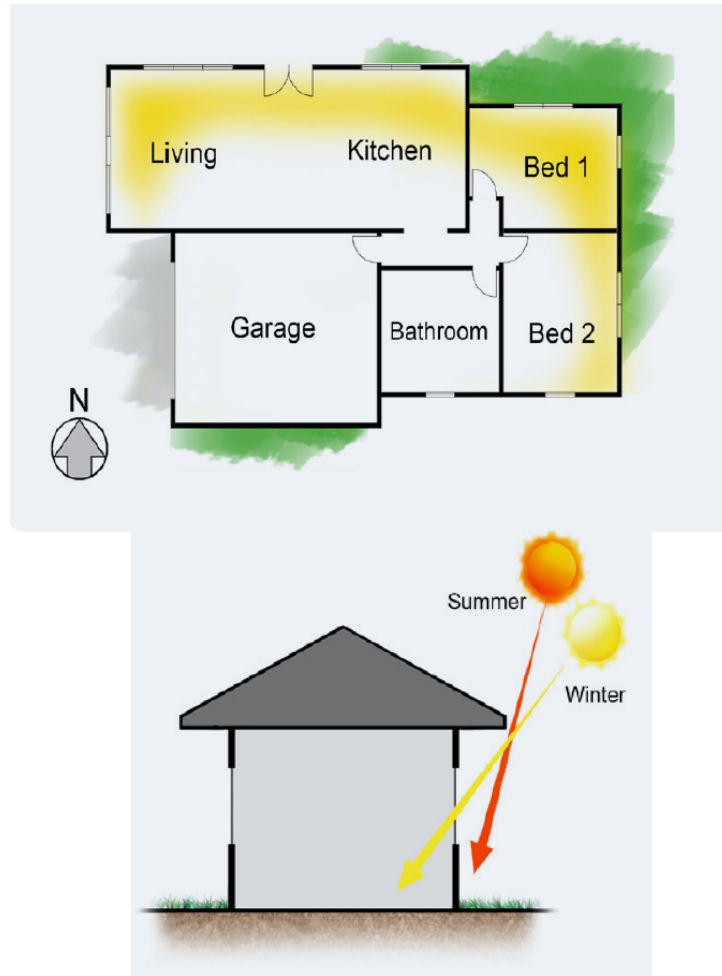


# Key strategies for design and construction





# Solar Access – Yes or No



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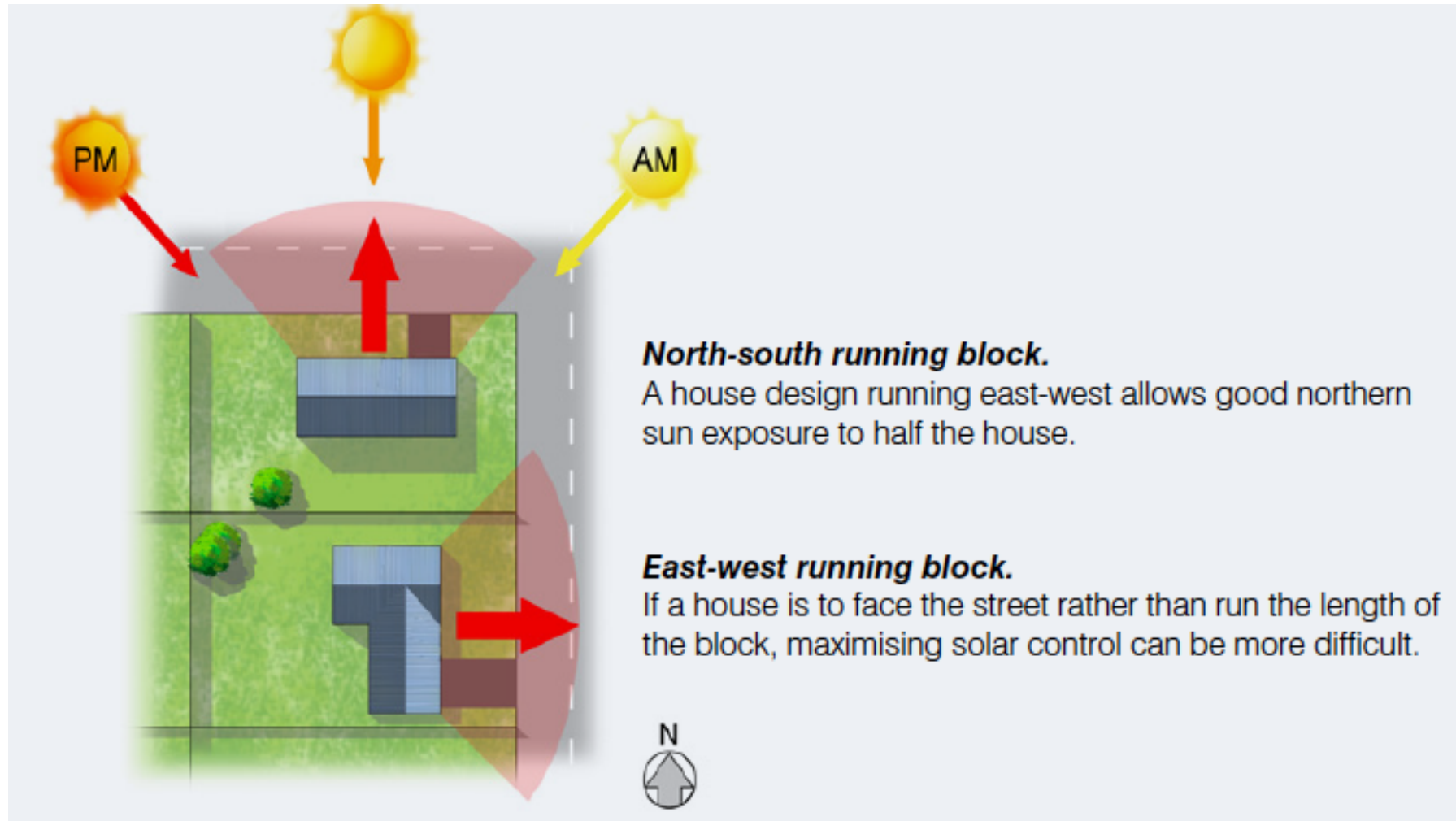


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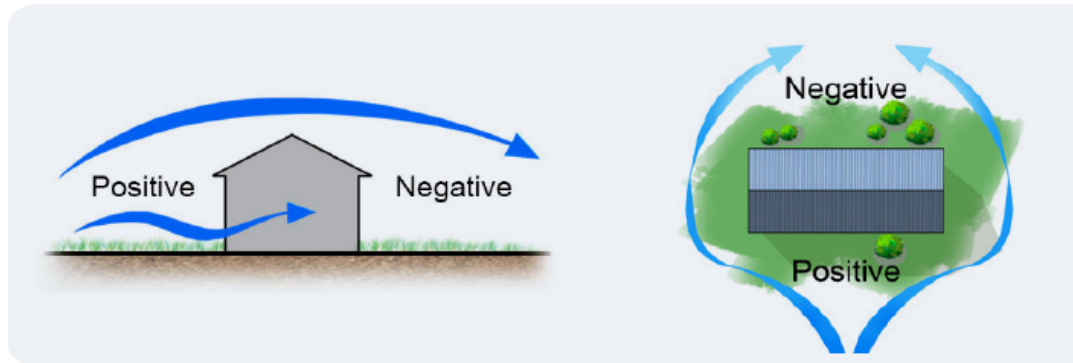


# Solar Access – Yes or No

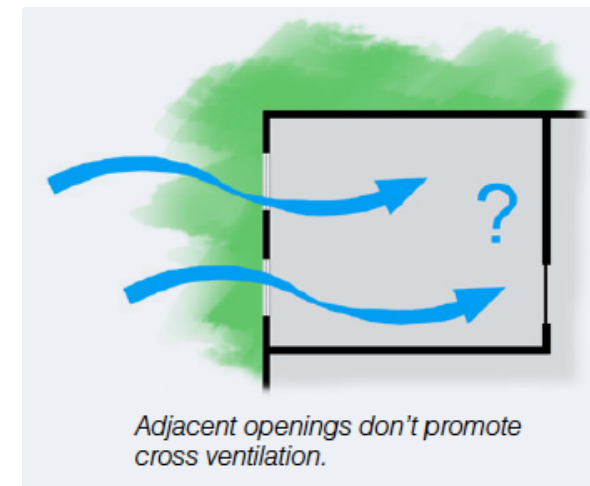
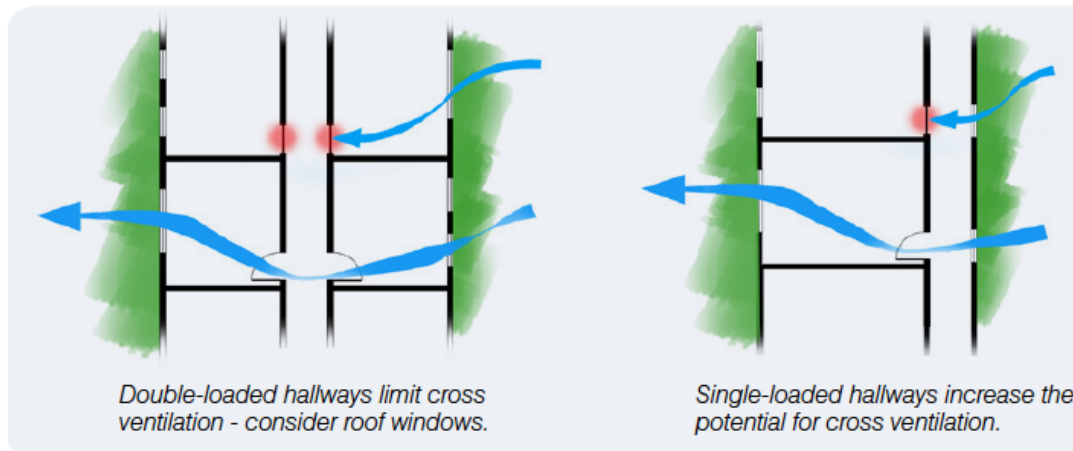
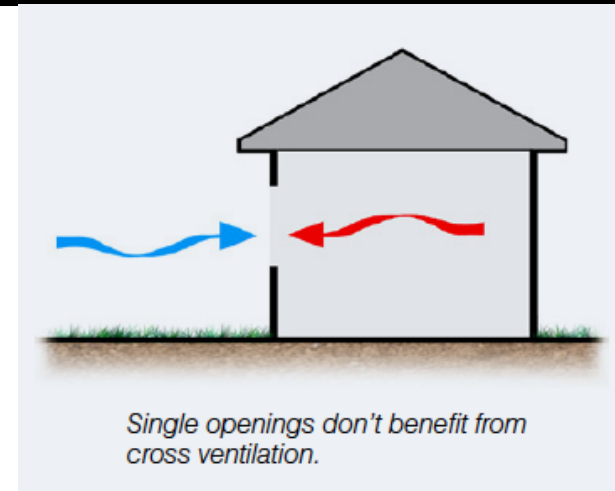


# Ventilation

## Ventilation of buildings

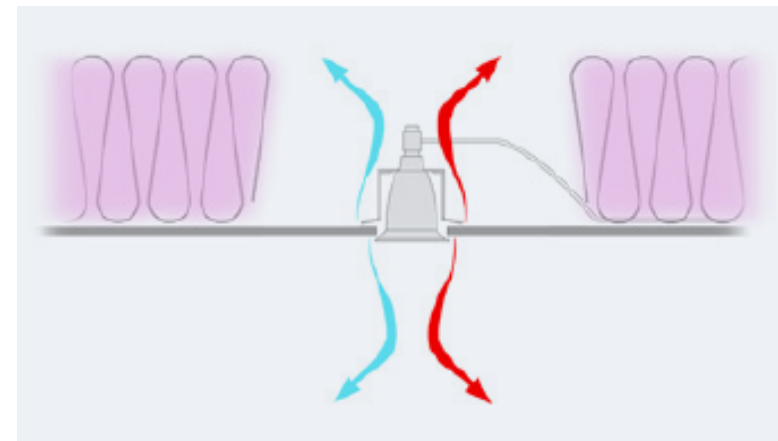
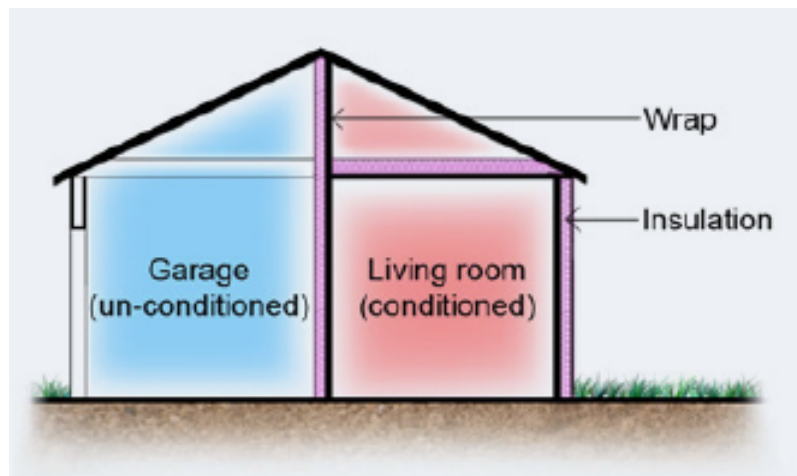
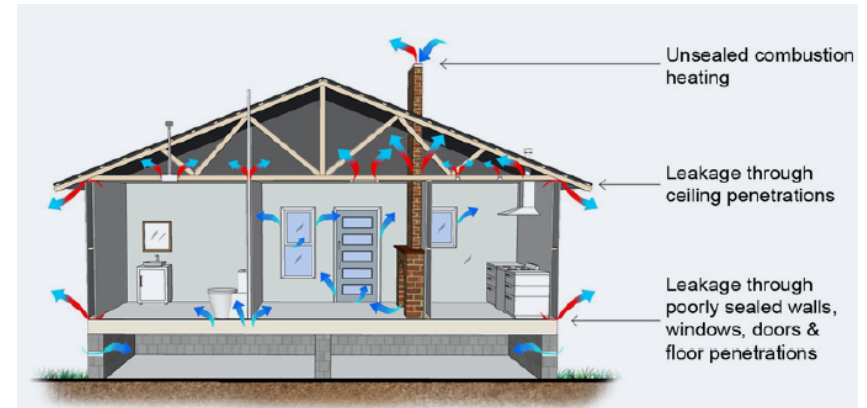


**Figure 15: Wind pressures on buildings.**  
Wind creates differential air pressures on the windward and leeward sides of the house.



# The Built Envelope

**Structural moisture control**  
**Vapour management**  
**Air tightness**  
**Insulation**



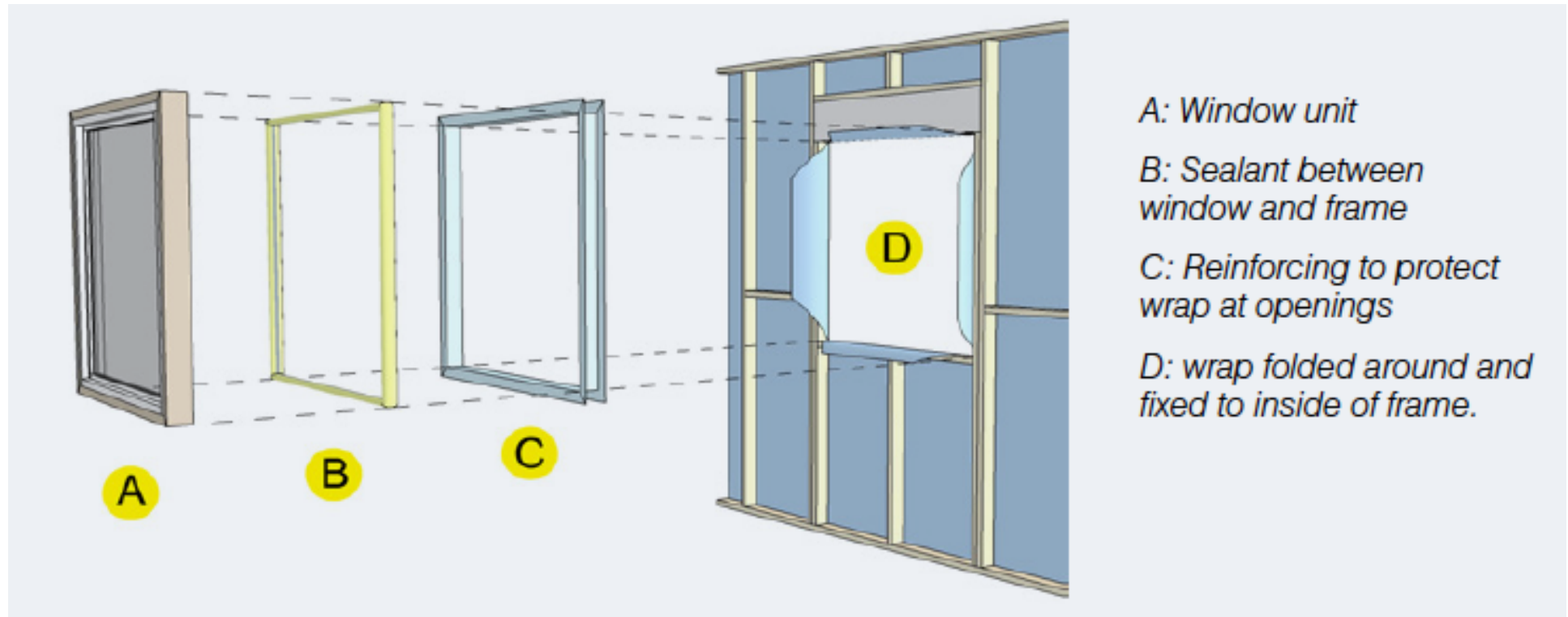
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# Building wrapping



# Vapour management

Vapour impermeable	Vapour semi-impermeable	Vapour semi-permeable	Vapour permeable
Polyethylene Vinyl Glass Aluminium foil Sheet metal Foil-faced insulation	Oil-based paints Some vinyl wall coverings Extruded polystyrene Paper-faced bulk insulation	Plywood Particleboard Expanded polystyrene Most plastic paints	Unpainted paper-faced plasterboard Unpainted plaster Bulk insulation such as rock-wool, glass-wool and polyester Cellulose insulation Timber Clay bricks Concrete blocks



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## Climate specific considerations – showing vapour travel direction:

Zones 1 and 2 <i>Hot and humid</i>	Zones 3 and 4 <i>Hot and dry</i>	Zones 5 and 6 <i>Temperate</i>	Zones 7 and 8 <i>Cool temperate and cold climates</i>
<ul style="list-style-type: none"> <li>• <b>Refrigerated A/C</b> – this creates dryer internal conditions, therefore adopt impermeable wrap to avoid moisture ingress</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Cooling system</b> – if evaporative cooling is used adopt a vapour permeable system</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Vapour reversal</b> – adopt a vapour permeable system in this climate due to frequent reversal of vapour pressure</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Walls</b> – generally can be permeable</li> <li>• <b>Ceilings</b> – constant vapour migration into roof spaces can cause rapid decay of structure. Application-specific permeability requirements should be confirmed with wrap manufacturers</li> </ul>
<b>General direction of vapour flow</b>			
• inward	• both directions	• both directions	• both directions
<b>When heating is in use</b>			
• N/A	• outward	• outward	• outward
<b>Refrigerated air-conditioning</b>			
• inward	• inward	• inward	• inward
<b>Evaporative cooler</b>			
• N/A	• outward	• outward	• outward
Be sure to consult a suitable manufacturer about the building wrap system for your house in your climate with your heating and/or cooling system.			



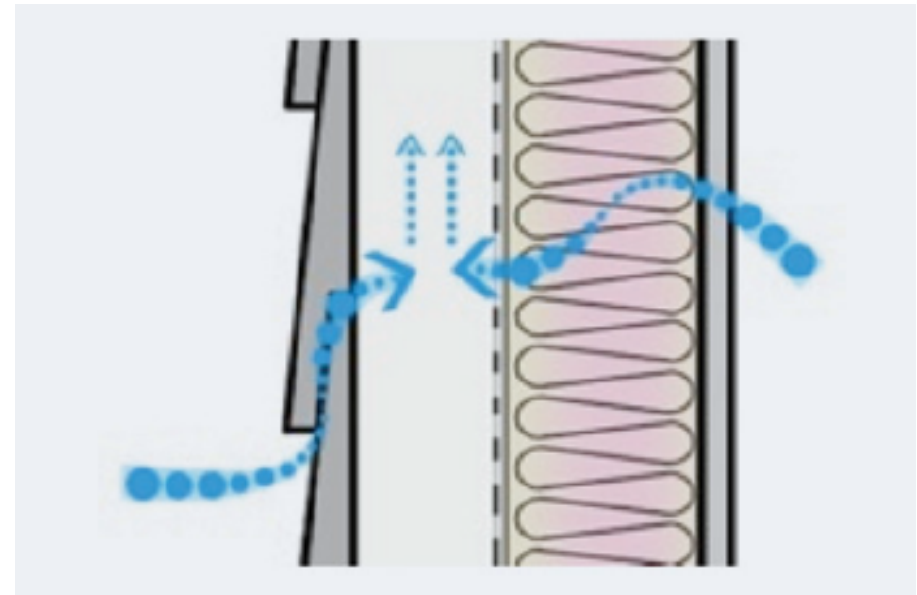
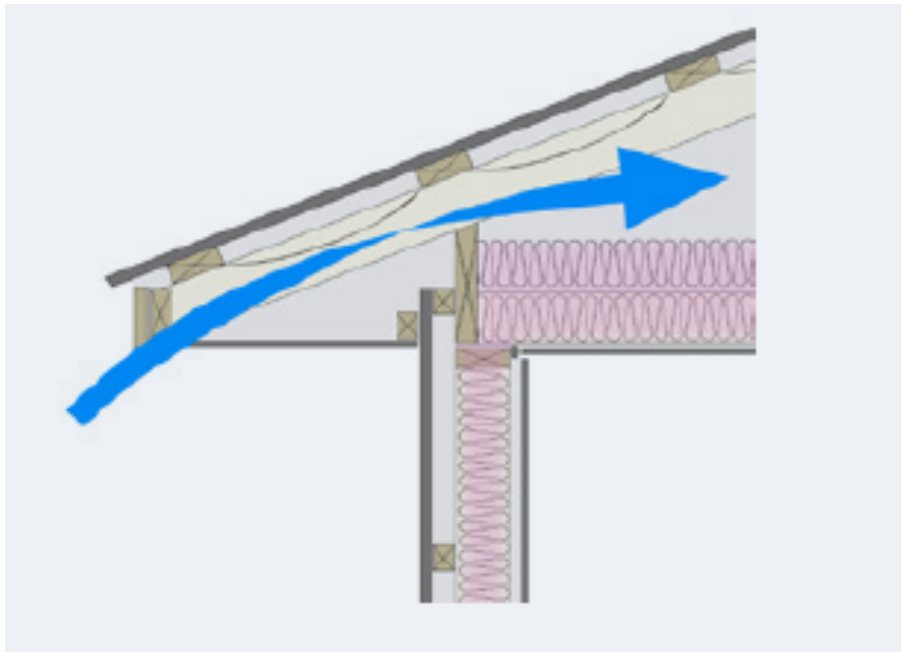
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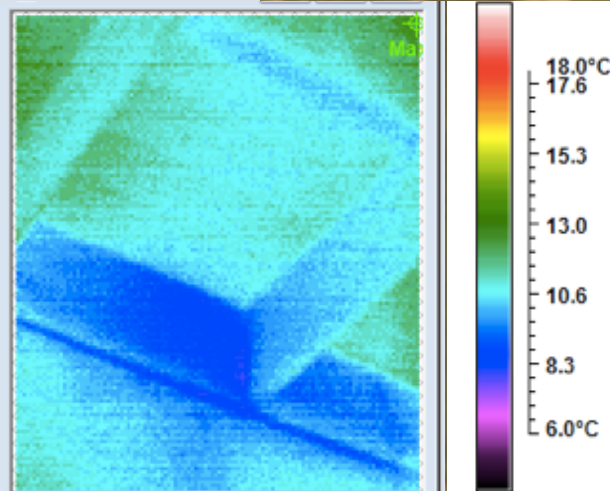


# Vapour management



# Insulation

Material	Thermal Resistance R-value (m.k)/W
General fabric materials	
Aluminium	0.000
Steel	0.002
Glass	0.004
Paper Faced Plasterboard	0.063
Clay Brick Extruded	0.179
Timber – Hardwood	0.523
Timber – Softwood	0.818
<b><i>Insulation products</i></b>	
Glass Wool Insulation	2.045
Expanded Polystyrene	2.308



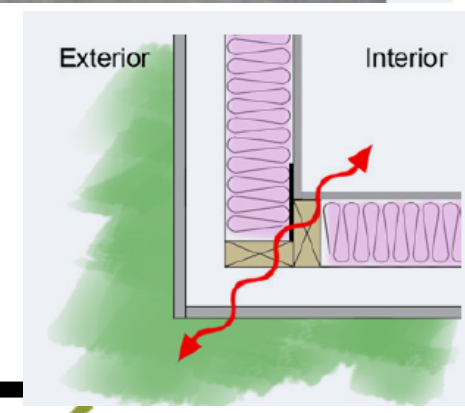
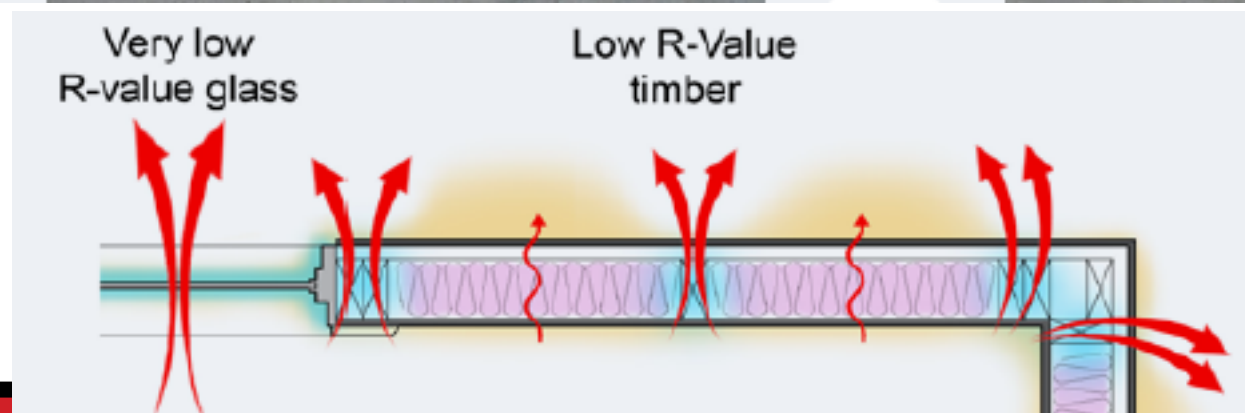
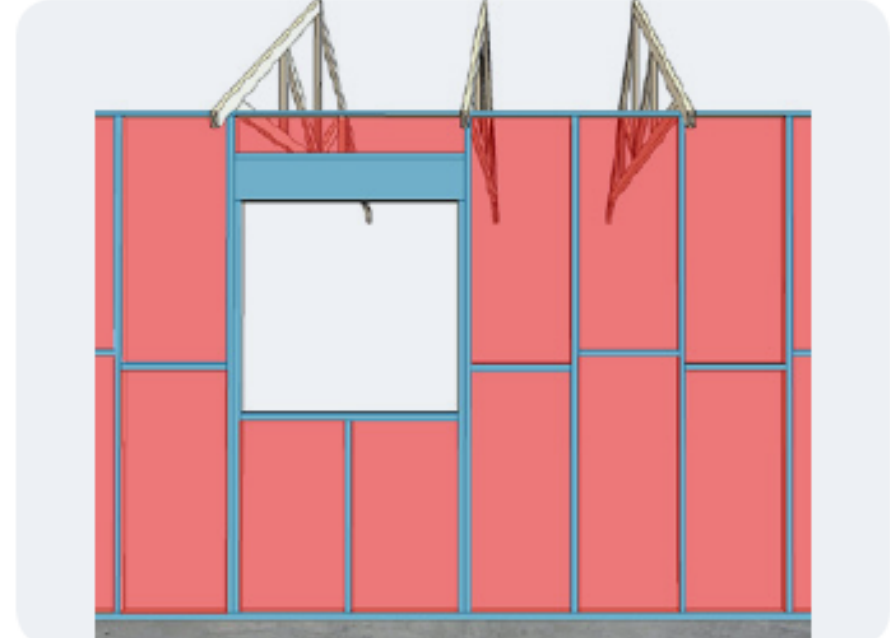
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# Envelope insulation & thermal bridging



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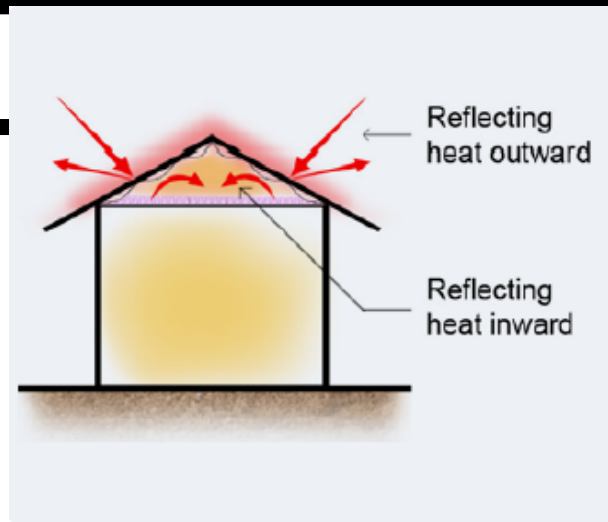


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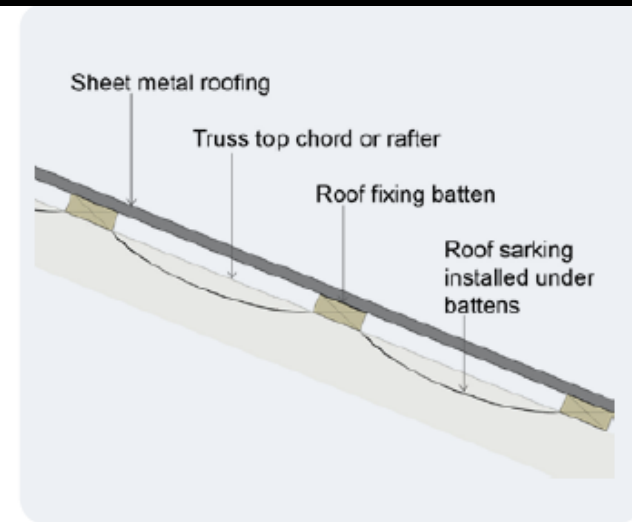




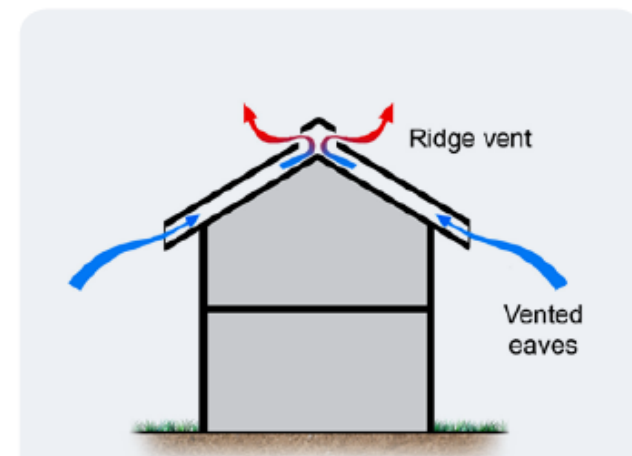
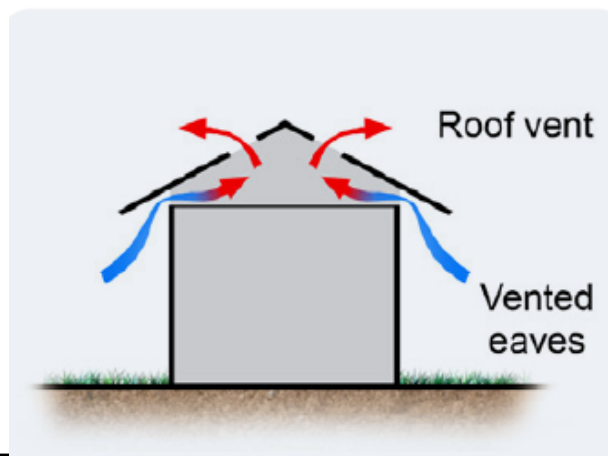
# Roof Space Design



**Figure 61: Reflective insulation in the roof**  
Reflecting internal and external heat.



**Figure 62: Alternate roof sarking detail.**  
Sarking under rather over battens allows condensation to form outside the roof space rather than inside it.





# Windows

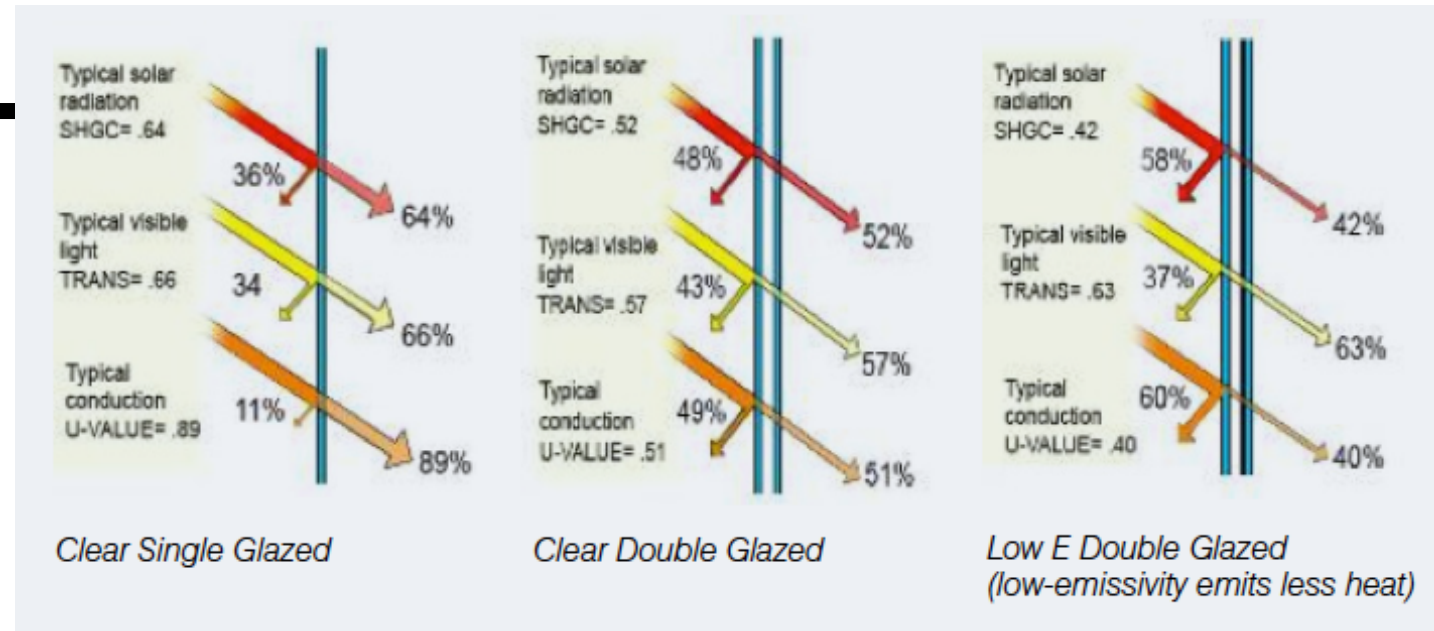


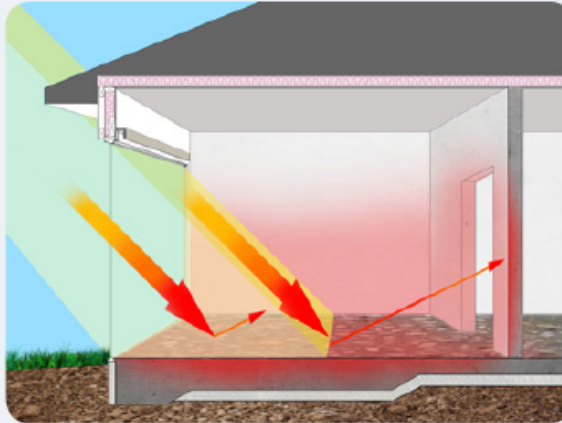
Figure 65: Heat flow through glazing.

Frame Type	Conductivity Value
Aluminium	8.0 – 12.0
Thermally broken aluminium	1.9- 3.5
UPVC	2.0 – 4.0
Timber – aluminium composite	2.5 – 10.0
Timber	2.0 – 3.0

Figure 66: Conductivity values for different frame types

# Thermal Mass

*Harnessing warmth of day for warmer nights*

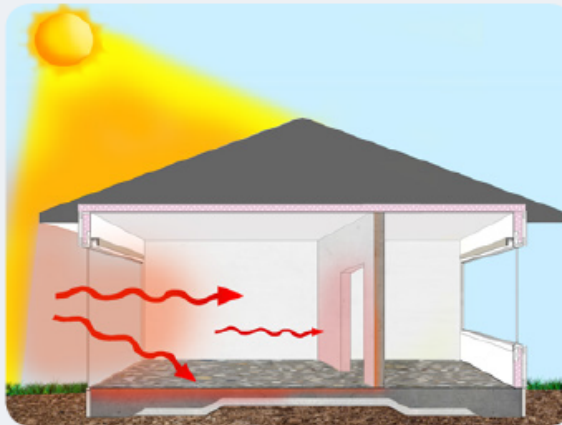


*Daytime heat absorption*

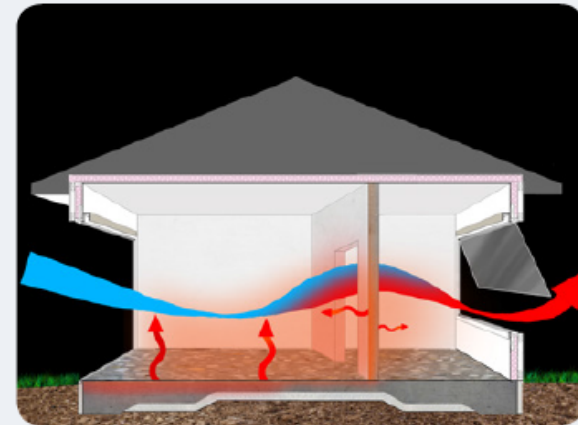


*Night-time heat release*

*Harnessing cool of night for cooler days*



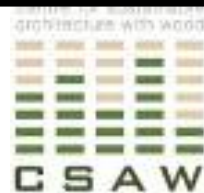
*Daytime heat absorption*



*Night-time heat release*



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# Thermal Mass

Material	Density Kg/m <sup>3</sup>	Specific Heat J/(kg.K)	Thermal Capacitance kJ/m <sup>3</sup> .K (1m <sup>3</sup> )
Air	0	1	0
Glass wool insulation	12	840	10
Paper faced plasterboard (6.8kg/m <sup>2</sup> )	680	1090	741
Softwood (pine)	500	1630	815
Hardwood (Euc. Obliqua)	780	1630	1271
Clay brick extruded	1700	800	1360
Concrete	2300	840	1932
Aluminium	2700	877	2367
Steel (AISE-SAE 1020)	7860	490	3851

**Table 16: Thermal capacitance values for common building materials.**



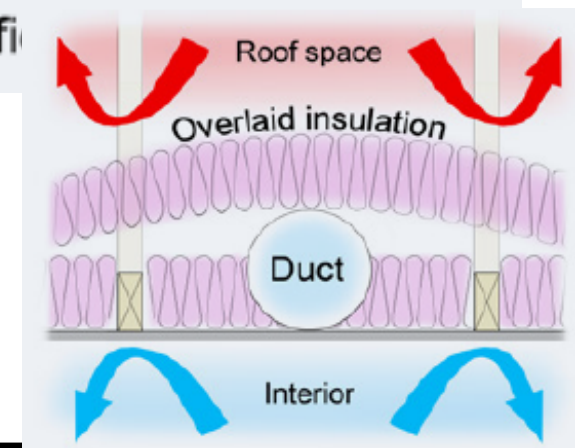
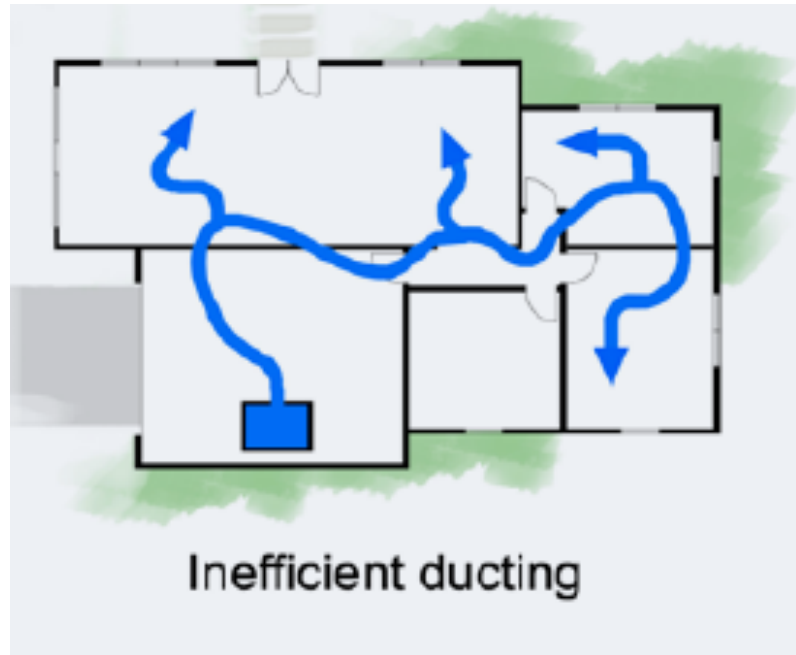
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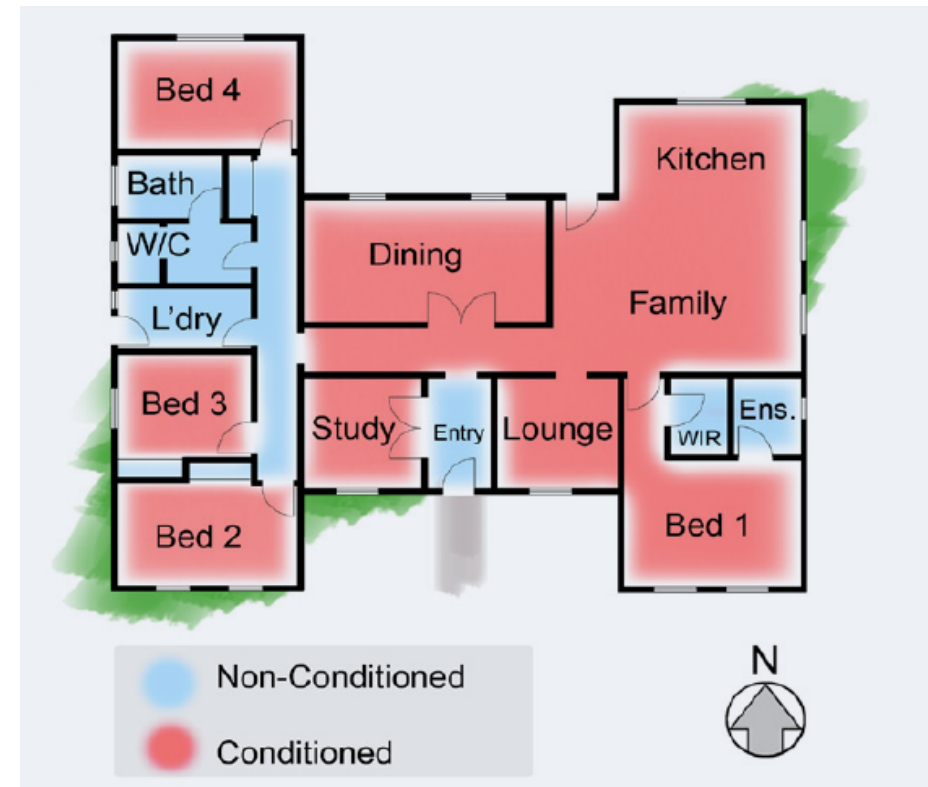
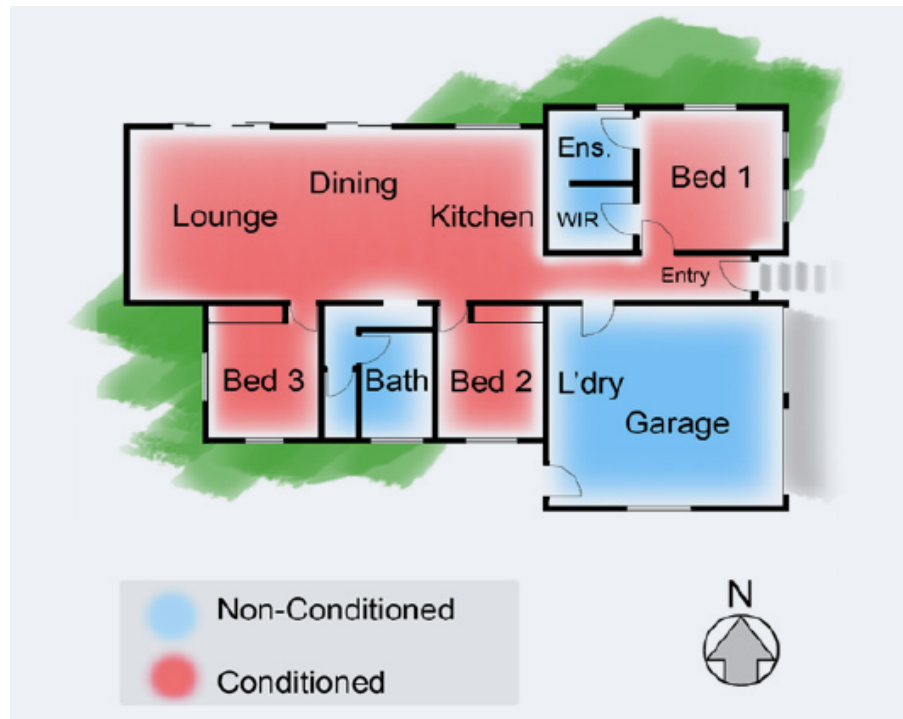
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# Ducted Systems



# Case Studies





Platform Floored Case Study House	Hobart 7000				Melbourne 3053				Adelaide 5000				Alice Springs 870				Brisbane 4000				Broome 6725			
	MJ/m <sup>2</sup> .annum				MJ/m <sup>2</sup> .annum				MJ/m <sup>2</sup> .annum				MJ/m <sup>2</sup> .annum				MJ/m <sup>2</sup> .annum				MJ/m <sup>2</sup> .annum			
	Star Rating	Heating	Cooling	Total	Star Rating	Heating	Cooling	Total	Star Rating	Heating	Cooling	Total	Star Rating	Heating	Cooling	Total	Star Rating	Heating	Cooling	Total	Star Rating	Heating	Cooling	Total
Base Design, carpet, R1.0 subfloor insulation, no eaves	5.4	167.5	13.8	181.3	5.1	106.0	40.7	146.7	4.7	62.9	74.7	137.6	4.1	33.0	158.8	191.8	3.2	14.8	76.2	91.0	3.9	0.1	390.4	390.5
Base Design + 90deg change of orientation to West	5.0	185.5	15.0	200.5	4.8	117.7	42.2	159.9	4.4	69.5	77.8	147.3	3.6	40.7	182.3	223.0	2.9	18.3	84.2	102.5	3.6	0.4	410.5	410.9
Base Design + 270deg change of orientation to East	5.2	180.7	9.0	189.7	4.8	113.0	45.0	158.0	4.4	66.0	82.2	148.2	3.6	32.7	186.6	219.3	2.7	15.4	91.2	106.6	3.5	0.1	413.5	413.6
Base Design + 450 Eaves	5.3	181.8	6.5	188.3	5.1	116.2	30.1	146.3	4.9	69.4	59.0	128.4	4.6	36.3	130.3	166.6	3.9	16.8	57.0	73.8	4.8	0.1	345.4	345.5
Base Design + 600 Eaves	5.2	186.8	4.8	191.6	5.1	119.5	27.1	146.6	4.9	71.7	54.5	126.2	4.7	37.5	123.0	160.5	4.1	17.5	51.1	68.6	5.0	0.1	334.2	334.3
Base Design + 1800 Shade	4.6	219.0	1.9	220.9	4.7	141.6	19.7	161.3	4.9	87.3	41.3	128.6	4.9	48.1	100.3	148.4	4.5	22.9	38.6	61.5	5.9	0.2	288.6	288.8
Base Design no recessed down lights	5.7	152.6	14.1	166.7	5.4	96.1	40.1	136.2	4.9	56.1	73.7	129.8	4.2	28.9	157.8	186.7	3.4	12.8	74.0	86.8	4.5	0.1	358.6	358.7
Base Design + R2.5 Insulation to entire floor	5.7	154.2	15.0	169.2	5.2	98.8	43.8	142.6	4.7	59.6	77.5	137.1	4.0	32.7	163.3	196.0	3.1	14.4	80.5	94.9	3.9	0.1	391.2	391.3
Base Design + R 2.5 wall insulation	5.6	160.6	13.3	173.9	5.2	101.5	40.1	141.6	4.8	59.9	73.2	133.1	4.2	31.4	155.4	186.8	3.3	14.1	75.6	89.7	4.0	0.1	386.4	386.5
Base Design + R8 ceiling insulation	5.7	156.6	13.3	169.9	5.3	98.4	39.0	137.4	4.9	57.4	70.2	127.6	4.3	29.0	149.2	178.2	3.3	12.8	75.8	88.6	4.1	0.0	382.4	382.4
Base Design + door to air lock	5.4	167.4	13.8	181.2	5.1	106.0	40.4	146.4	4.7	62.8	74.5	137.3	4.1	32.9	158.9	191.8	3.2	14.8	76.7	91.5	3.9	0.1	391.5	391.6
Base Design + Tiles to dining, lounge and hall floors	5.3	176.3	10.8	187.1	5.0	112.2	36.0	148.2	4.8	66.3	67.1	133.4	4.4	34.4	142.4	176.8	3.5	15.6	67.1	82.7	4.2	0.1	375.3	375.4
Base Design + additional windows for cross ventilation (up to 16% floor area)	4.7	187.3	30.0	217.3	4.3	119.1	61.1	180.2	3.7	72.9	108.2	181.1	3.1	39.1	225.3	264.4	1.9	17.7	122.3	140.0	2.6	0.2	480.1	480.3
Base Design + additional windows for cross ventilation (up to 16% floor area) + 1800 Shade	4.3	237.3	3.5	240.8	4.3	154.2	26.1	180.3	4.3	96.3	54.2	150.5	4.2	53.6	130.8	184.4	3.9	25.4	46.5	71.9	5.1	0.3	329.3	329.6
Base Design + double glazing to living, dining and kitchen	5.8	155.6	10.2	165.8	5.4	97.6	34.7	132.3	5.1	57.5	64.3	121.8	4.5	30.5	138.5	169.0	3.7	13.4	65.2	78.6	4.4	0.1	361.8	361.9
Base Design + double glazing to all rooms	5.9	147.1	10.1	157.2	5.6	92.3	33.8	126.1	5.3	53.9	62.2	116.1	4.7	27.8	132.1	159.9	3.7	12.3	65.5	77.8	4.6	0.1	356.4	356.5
Base Design + added thermal mass to internal walls of northern rooms	5.6	160.9	9.9	170.8	5.4	101.1	32.8	133.9	5.2	55.4	63.8	119.2	4.9	23.6	125.4	149.0	3.7	9.9	67.4	77.3	4.2	0.0	376.9	376.9
Base Design + added thermal mass to internal walls of all rooms	5.4	169.3	9.9	179.2	5.3	106.4	31.5	137.9	5.2	58.2	61.4	119.6	5.1	23.7	119.4	143.1	3.4	10.2	74.0	84.2	4.1	0.0	383.3	383.3
Base Design + added thermal mass to Floor (mass timber)	5.8	151.4	12.0	163.4	5.5	93.9	35.9	129.8	5.2	52.7	67.2	119.9	4.5	24.3	143.9	168.2	3.6	10.1	70.1	80.2	4.2	0.0	376.0	376.0



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