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Finally, thanks to my wife, Penny, for the time we spent driving and walking the streets looking for the bad examples of tropical design.

Disclaimer

The content of this publication does not necessarily represent the position of our sponsors.

This book is designed to be read in conjunction with the COOLmob Greenhouse Friendly Hardware for the Tropics and COOLmob Greenhouse Friendly Habits in the Top End Booklets.
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Chief Minister’s Foreword

Congratulations to COOLmob on developing this wonderful community resource for Territorians. It complements the actions being taken by my Government in its “Greening the Territory” initiative. Whether you are building, buying or selecting where to rent, you will find this book useful.

The material presented here will ensure that you have useful information when taking your first step towards choosing your own home. You can make informed decisions now that will save considerable money over the coming years in lower power and water bills.

A well designed house does not require lots of additional cooling and will increase your comfort and quality of life. By taking into account the information presented here you can also live more sustainably and reduce your carbon footprint on our planet.

This book compliments the COOLmob Greenhouse Friendly Hardware and Greenhouse Friendly Habits books also produced by COOLmob.

Paul Henderson
April 2011
Preface

In 2007 COOLmob developed a household comparison system based on the number of kilograms of carbon dioxide (CO2) being emitted per person per day from homes we had already audited. Apart from those households on the extremities, we were able to decide on a close fit straight line from the graph giving a 0-10 star rating (0 worst cases) with the mid range households being 5. *(Appendix 1.1)*

COOLmob has increased our areas of audit coverage to include the newer suburbs of Palmerston and more of the ground level private homes in the northern suburbs. In these areas we have found a tendency for the houses to have increased consumption of energy per person per day. The new designs are relying far too much on unsustainable, consumptive technologies. Take note of the number of air conditioners now being installed in these new homes instead of adapting the design to our climate.

It is estimated the average household with air conditioning (one in each bedroom and one in the lounge room) will spend approximately $60,000 *(Appendix 1.2)* on power costs over the next ten years and produce over 145 tonnes of greenhouse gases with this level of consumption.

We believe that the current trends in housing design and the increased use of electrical appliances need to be reversed. Only by doing this will we be able to lessen our impact on the environment and reduce the amount spent on electricity. COOLmob has identified a need for more public advice in this area so this booklet has been produced to help the public:

- To identify positive and negative features of houses with regards to energy consumption when designing, building, modifying or renting homes.
- To reduce their costs and the carbon footprint they produce through the amount of energy consumed in their home.
Why sustainable design?

For centuries humans have known how to build houses that utilise the elements to achieve comfortable living conditions.

In the Middle East, adobe houses were the order of the day. They were built to catch breezes, utilise the cooling effect of water and their design and orientation limited the ingress of direct sunlight.

Even Australia’s European settlers, limited by the available building materials, built houses that opened up to allow through-ventilation, despite being made from galvanised iron. They used simple concepts such as high pitched roofs with vents that maximised the gain from induced ventilation.

So why is it that today, with all the advances in science, technology and materials, we build houses that require such high amounts of energy to provide acceptable living conditions?

As a society we now demand better living conditions as standard. However our increased energy consumption far outweighs the improvement in conditions. We have forgotten what our forbearers taught us! Relying only on air conditioning to cool your home is as logical as running a refrigerator inside an oven.

The negative effect on our environment caused by this increased energy consumption will increase. We all have

"Windcatchers", Yazd, Iran

Breezes are directed down into the houses and the hot air forced out on the “downwind” side.

Ice storage, Abarqu, Iran

During hot summer months ice was stored in these mud structures without the need for the energy consuming complex refrigeration systems of today.
a responsibility to the environment. Just because someone can afford higher power costs or because we are compensated for the provision of the air conditioning doesn’t mean we should be using it.

It is now time to revisit some of the historical knowledge of our ancestors. By doing so, we can reduce our consumption, save money and help our planet.

A win/win situation, how good does it get!

The suggestions made in this booklet are provided to help in your decision making and with well-considered early planning reduce your on-going power costs. This may ultimately give you a property with a higher resale value as the impact of rising energy costs really hit home.

**COOL TIP**

Your home is probably the most expensive purchase you will ever make. Careful thought and planning now can save you a lot of money and future discomfort.
Getting Started

This section provides information on the important starting points for your house, basic orientation and layout, initial block choice, siting of your house and getting the groundwork right. Get these right and you are on the way to building a home with low energy use

Selecting a Block of Land

Did you know that the way your house sits on your block can have a big impact on your energy bills?

When looking to buy land ensure the block will allow you to orientate your home in the direction that will minimise heat load on your walls and catch prevailing breezes.

The main starting parameters are orientation with consideration of shade and breeze:

1. North or south facing walls offer the best opportunity for shading sun on windows and walls by the use of eave overhangs which don’t obstruct breezes.¹

2. Ensure the layout/design of your home is such that natural ventilation is used to the maximum.

Look for

- blocks facing a street running east/west that have long frontage and less depth, or
- blocks facing a street running north/south that have less frontage to the street and greater depth, or
- blocks facing streets aligned north-west/south-east or north-east/south-west that have equal frontage and depth. This will allow steps in external walls that provide self-shading to walls from the low angles of the afternoon sun, or alternatively, rotation of the house plan to orientate long walls to the north and south

Have some idea of your house shape and layout and make sure that you can position it on the block for good orientation. Do this before you buy your block of land! This is the most important factor in giving you a good start in minimising the carbon footprint of your home. Remember, the money you save by buying an unsuitable block with poor orientation may well cost you many times more in providing shading and/or cooling (energy) costs over the following years particularly as energy prices rise, and they will!

It’s important to select the “right” block

Acceptable

Not acceptable

Acceptable provided “self-shading walls” incorporated into the design

Investigation has shown that good block developments can be achieved. Some sub-divisions are being developed that not only specify the environmental requirements for each of the houses on the sub-division but have also ensured that with correct block layout and the retention of open spaces homes are guaranteed reasonable access to prevailing breezes.

With the current reduction in block size, reduction in space between houses, increased use of solid fences, and combined with the increase in ground level houses the opportunity for house designers to make use of natural breezes is limited. The use of “gaps” in solid fences provides very minor increases in available breezes and is really only a token gesture.
House Shape and Style

Correctly orientated house, well shaded and designed to utilise the predominate breezes.

Modern house designs are often irregular in shape with several external angles. Roofs that are more complex result in higher construction costs as well as making the future installation of photo voltaic (PV) panels, solar hot water (SWH) systems and the collection of water for rain water tanks more difficult and expensive.

A simple rectangular design makes the above additions much simpler. Provided the orientation is correct, easier control of the heat load on the building is available and maximum natural ventilation can be achieved. In the following example the 900mm wide eaves on the southern section of the house near the living areas will provide shade to the walls and windows from direct sunlight.
Elevated versus Ground Level

In recent years, fewer elevated houses have been built and the ground level blockwork house has become more popular. However, the elevated house does have a number of advantages for tropical living:

- The house takes up less space on the block increasing your ability to orientate the house correctly, and also freeing up space for plants and verandahs that provide external shading.
- The under house space can be used for car parking, storage, laundry facilities and entertainment areas.
- The area under the house also acts as an under-cover play area for children during the Wet Season.
- Under house areas can be used for clothes drying during the Wet Season eliminating the need for an electric clothes drier.
- Lightweight construction means that the walls cool down much quicker once the heat source (ie the sun) has set, than the heavier concrete block construction.
- The elevated house has the ability to catch a breeze more easily than the ground level house.

These advantages are becoming increasingly important as block sizes reduce.

Conversely, the elevated house can have the problem of heat gain through the floor which will be discussed later.

Orientation and Siting of your Home

Good orientation is an essential start if you want a low energy consuming home. In the future your home may have a higher resale value as we recognise the economic and environmental value in good decisions being made at the design stage.

Poor orientation contributes considerably to the heat load of a house. It adds to construction costs as verandahs, extended eaves, insulation or other passive solutions are required to offset the increased heat gains. Gaining a good star rating for your home will be significantly more difficult if handicapped by poor orientation.

To prevent low morning and afternoon sun from heating up the house, minimise the size of east and west facing wall areas and avoid windows in these walls unless well shaded.

The top house clearly shows how correct orientation reduces the effect of the sun on your house by reducing the area of walls affected by low morning and afternoon sun.
The exposure of walls and windows on the western and eastern sides of your house can be critical. Research shows that “residential tree cover cooled surface temperatures in the relatively mild month of October 1999 by up to 5 degrees Celsius. When applying the effects of tree shade on the eastern and western sides of a single storey, 3 star energy-rated home, energy savings of up to 50% per annum could be achieved.” ²

For those living “down south” orientation is a compromise between avoiding the summer sun and using the winter sun to heat your home; whilst here in Darwin it is much simpler.

For Darwin, east west orientation reduces the heat load through the external walls provided the eaves are of sufficient width to provide the wall shading. Even for an elevated house the size of eaves required is in the order of 900 to 1200mm depending on which side of the house. This is a very minor increase in the cost of a house.

**Coolmod TIP**

Every home needs to be designed specifically for the site that it is intended for. Design your house on an east–west axis (or within +/- 10°) for less direct sun on your walls and consequent heat gain. Ensure living areas are located to receive as much access to prevailing breezes as possible.

The “face the street” mentality, highlighted by Derek F Wrigley in his document “Climate change needs housing change”, sadly has also crept into much of the housing design in the newer suburbs and replacement houses in the older suburbs of Darwin. The double garage, front door, lounge room and main bedroom across the front is repeated in house after house with little regard to the orientation or shading.

² T Hall in his paper “The Death of the Australian Backyard – A Lesson for Canberra” cited research carried out by L Plant for the City Council of Brisbane.

Ensure your home is located far enough back from the street to enable plants to provide shading, privacy and reduce the nuisance noise and light (both street and traffic) from the street. This will ensure that you can live comfortably in your home with adequate privacy without the need for heavy drapes and curtains which severely restrict available breezes. The need to keep out street noise will result in shut windows and therefore the unavoidable use of air conditioning.

**Ventilation**

Cooling through natural ventilation demands a good exposure of the building and its windows to the dominant breezes.

However, with the

- reduction in block size,
- the increase in house size
- the predominance of ground level houses
- the reduction in the distance between houses, and
- the construction of solid fences to provide privacy and to reduce noise interference,

your ability to catch the predominate breezes is severely reduced. Research has shown that with houses blocked together like most houses are, the breeze flows over the roof not penetrating down into the house.
Pathway of breezes around and above closely positioned ground level houses in new sub-divisions

“The dwellings in the newer suburbs are generally of deep-plan layout with small windows. Their design relies on air conditioning for them to be habitable. However, even if they had been designed for natural ventilation, the reduction in width between the dwellings would make this very difficult, especially in those parts of Australia with subtropical climates. A study by Lee Su San (1998) of suburban development in the Douglas area of Townsville revealed that the narrowness of the gaps between the houses prevented airflow around them, creating a “heat island effect”. Her studies of actual buildings confirmed previous experimental results from wind-tunnel tests with models of buildings (Lee, Hussain and Soliman, 1980). For single-storey dwellings with a comparatively narrow gap between them, the prevailing winds skim over the roofs without exerting air pressure within the gaps to force natural ventilation. Natural ventilation of houses from the wind is increased if the buildings are two, rather than one, storey high. The problem was exacerbated by the exhaust from the air conditioners and the dark coloured roofs which absorbed, rather than reflected, the heat.”

4 Hall, T. “The Death of the Australian Backyard – A Lesson for Canberra”
Orientation/breeze conflict

Our hot climate demands high cooling loads during most of the year; therefore minimising sun exposure should take precedence over maximising wind exposure (whenever they conflict). In most cases, the conflict between exposure to sun or prevailing breezes is a false one as there are several ways to deflect breezes into buildings, even when the building doesn’t have the best exposure to wind.

The use of Wing Walls is one method. Simple solid panels located alongside windows redirects cooler breezes into the home and also pulls the hotter air out (wing walls also accelerate the natural breeze speed, due to the differences of pressure they create). They can be constructed as an architectural feature using various decorative materials. Casement windows also provide a similar action though on a lesser scale.

Some designs use this fact in a more radical way. They involve a wing wall at the downwind end of the home (in order to create a positive pressure zone there) and another similar wing wall on the leeward side (at the upwind end, to create a negative pressure zone); this design ensures stronger cross ventilation. Casement type windows, large open areas of louvres and sliding doors/walls will improve the catching of breezes.

Air conditioning is often used to achieve comfortable sleeping conditions by lowering temperatures and humidity. The number of operating hours required for air conditioning to achieve thermal comfort can be substantially reduced (or eliminated) by careful design of new homes, alterations and additions.

Placement of Solar panels

The simple roof line of an elevated house with east west orientation suits installation of solar panels. Vegetation on the western end wall provides shade to the main bedroom in the afternoon while still allowing cool breezes to enter the house. It also provides shade to the western end of the northern verandah in late afternoon. Minimal high vegetation on northern side ensures that solar equipment receives maximum sunlight between 10am and 3pm, the most productive sunlight hours.

We can’t change the sun’s path, but we can deflect breezes.
Size of house – Build better not bigger

In her article “Size Matters” journalist Jenny Brown finds that Australians have been building bigger houses, an increase of 50m² since 1986. With block sizes being reduced this has resulted in much less space around and between houses reducing the cooling and shading that can result from a well developed garden. The larger houses are of course more expensive and certainly less sustainable.

Think carefully about what you really need. A bigger house means you will have less garden space and more house to cool, light, clean and furnish. This adds to your costs both now and in the future.

Smaller well designed houses can fulfil our needs and result in savings of up to 1 tonne of carbon emissions per year.

“In the US, pressure on available land is prompting the beginning of what appears to be a rationalisation of house size.” American based architect Sarah Susanka in her book “The not so big house says "Build better, not bigger "and “scale is the first consideration of sustainability.”

A wide verandah ensures the northern wall is shaded all day.

As the northern wall is well protected from the sun, dark colours could be used without the wall absorbing heat from the sun. The lined ceiling, (also fitted with “sisalation”), reduces the radiant heat that would otherwise heat those sitting on the verandah and the walls.

Nearby vegetation creates an envelope of cool air around the house and encourages the circulation of cooling breezes.

5 Brown J, ATA “Sanctuary” Magazine – Issue 9 Pages 84 and 85 “Size matters”
Sustainable Living

For us to live sustainably we cannot continue to go on building these single dwellings on individual blocks creating urban sprawl and massive transportation problems. As the price of fuel rises so will the cost of our transport. Although a lot of Australians don’t like the idea we have to increase the density of our living if we want to live sustainably.

By definition, “densification” means increasing the number of units of housing per square metre of land, either through building on vacant land or allowing taller and larger structures but does not necessarily mean smaller block sizes with our houses taking up a greater share of the block.

Densification should be a deliberately planned and designed environment that allows the better use of a given area increasing the number of dwellings on the site but improving the environment, both physically and socially. It can be achieved by the development of environmentally friendly low energy houses, in “duplex” form, eliminating the wasted and useless space between houses, having correct orientation, reducing the amount of space needed for through traffic and developing community areas.

It is essential that this sensitive infill development occurs along efficient public transport corridors as part of the requirement is to reduce our reliance on cars and move away from the two car, double garage mentality.

This diagram is based on the same sub-division as shown on page 7. The first development had 46 sites, only 28 of which were considered suitable because of being able to correctly orientate the house. This alternative style of development has 49 suitably orientated residences plus an area for public facilities and services. The density can be increased even further if some two-storey residences and multi-storey units are included in the high density area.
The other suggested form of sustainable densification is the development of multistorey units. This does not however mean the current approach of building multistorey complexes filling most of the block with a building orientated only by the restrictions of the block boundaries and what is left of the block being covered in concrete and bitumen to create stormwater and heat sink problems. Densification does not mean cramming the maximum number of units into a development just to maximise the developer’s profit. Such a development has a lot of ongoing costs both socially and financially to both the tenants and the community in general.

Windows on eastern and western walls exposed to direct sunlight (depending on unit)
Large concreted areas with little permeable surface area creates the potential flooding
No facilities for naturally drying clothes
No use is made of predominant natural breezes

Dark coloured exposed walls on eastern elevation
Hot water not provided from solar
Minimal cross flow ventilation, if any
Concreted areas and heavy construction walls exposed to direct sunlight act as heat sinks
Narrow sliding windows
Incorrect orientation; both buildings orientated north–south

We need well designed, energy efficient and sustainable complexes adjacent to efficient public transport and facilities, removing the heavy reliance on vehicles and the need to provide excessive car parking. The complex design and layout should take into account noise pollution, stormwater control, grey water reuse and ensure that heat sinks are not developed. Open green space should be developed between these buildings to provide social and community areas and facilities.
The Structure

In this section you are given information to help in the selection of the best materials and design for your roof, walls, floors and windows to ensure the good work you started in the previous section is continued. The information is aimed at ensuring your home provides a comfortable environment with the minimum use of energy.

Design philosophy

There are three major schools of thought regarding housing design for tropical living:

1. light construction, for both elevated and ground level with maximum cross flow ventilation and minimal air conditioning, and

2. heavier type well insulated construction designed for high efficiency air conditioning use, and,

3. those in the middle, adopting the more air conditioned environment for bedrooms and open, well ventilated family and entertainment areas.

All three options however still rely on the principle of requiring good orientation and shading to reduce the heat load from the walls and windows. This is essential in all cases but is particularly vital for the air conditioned environment where operating costs can be severely increased as a result of poor design.

Design relying on full air conditioning to provide comfort is not environmentally friendly and this decision has the following disadvantages

- Occupants of these types of residences will experience ongoing problems in becoming acclimatised to our weather conditions.
- The cost of power will increase considerably as energy sources become more expensive and measures are put into place to reduce greenhouse emissions
The Roof

A roof pitch of around 12° will allow for maximum efficiency of your PV panels and SHW unit for the Darwin and Palmerston areas.

With or without appropriate shading of walls and correct orientation of your house the roof is one of the major sources of heat gain. A number of options can be adopted to reduce the effect of this major heat load.

Colour of roof

The colour of your roof is very important. Generally, the darker the roof the more heat is absorbed or conversely, the lighter the roof the more heat is reflected. The deterioration of the reflective properties of standard corrugated roof sheeting over a few years can have a noticeable effect on the heat absorption of this material.

Some roof paints that can be applied to the roof, claim very high levels of reflectivity but generally the adoption of a very light coloured or even unpainted natural “galvanised” finish will provide good levels of reflectivity particularly whilst the roof is relatively new.

Avoid a dark roof. They may look good, stylish, or “modern” but extra insulation and/or ventilation will be required just to get rid of the extra heat being absorbed into the structure. Better reflectivity is now achievable even with dark colours but they are not as good as the light colours and therefore require other additional work to overcome the extra heat load.

Ventilation of roof space

Ventilation of your roof space will ensure your home remains cooler. This can be in the form of roof vents, vents in the eaves and gables or some form of ridge venting.

The most common forms of roof vents are “whirlybirds” with up to three being required for an average household. One solar powered roof vent will provide considerably more ventilation (manufacturers claim twenty times one whirly) for a similar overall cost and only requires one roof penetration.

Using ventilation to cool the roof space
Using ventilation to cool the roof space

If the room is not to be air conditioned then the installation of insulation is not considered necessary and additional ventilation to the ceiling space can be provided in non-air conditioned spaces by inserting ceiling vents which will allow the air trapped beneath the ceiling to be drawn into the ceiling space and then out through a roof vent or whirly. This air, although warmer than the lower air in the room is generally cooler than outside and certainly cooler than the air it displaces in the ceiling space.

It is important when considering ventilation of the ceiling space that you are aware of the problems that can occur as a result of condensation if the air conditioning is set at too low a temperature. This is particularly important during times of high humidity and it may be necessary to have the insulation installed in plastic sheaths to act as a vapour barrier or have an effective full vapour barrier installed above the insulation to prevent the contact of warm moist air from outside directly with the insulation.

Cathedral type ceilings should be avoided unless specially treated. They appear to be very tropical and cool however this is only the case when properly ventilated at a high level or air conditioned. Effective insulation of cathedral ceilings is difficult and the lack of air gap in the ceiling means that it is harder to successfully ventilate that space and remove the hot air. In addition, the larger volume of air, if the area is to be air conditioned, will result in significantly increased cooling costs.

Airflow available to keep areas with “cathedral” type ceilings cool

Care needs to be taken to ensure that any ceiling fans are not just circulating the warm air trapped against the ceiling. They become more effective in providing cooling if installed on “droppers”, lowering them so that their resulting airflow can be felt.
Colour of walls/cladding

Any walls exposed to sunlight need to be a light colour to reduce the heat absorption. Insulating paints can also reduce heat absorption.

A preliminary investigation carried out on eight similar, identically orientated transportable accommodation units at a remote location in the Top End of the NT clearly showed that the darker coloured units on average (green versus beige) consumed more energy for air conditioning (on average 60% more even when excluding Unit 1 from the calculation) than the lighter coloured units.

Comparative Energy Use in Light and Dark Clad Transportable Dwellings
False Walls

The painting of a wall in a light colour, a reflective insulating paint or the provision of a “false wall” will provide a significant reduction in the amount of heat transmitted through the wall into your home.

The “false wall” is a simple way to provide shading to even an existing wall. It can be made of “corrugated iron” with an air gap to effectively provide a degree of insulation to the walls as well as reflecting a lot of heat. Timber battens, 40–50mm thick, need to be installed vertically to aid ventilation of the space behind the false wall. The use of wooden battens (non-heat conducting material) ensures a “heat bridge” is not formed between the sheeting and the wall.

Installing the sheeting with the corrugations vertically reduces the likelihood of dust and dirt collecting on the surface and aids the air circulation process.

Diagrammatic representation of a “false wall” showing the effect of the induced airflow
Glass Types

The type of glass selected considerably changes the amount of heat that enters a room.

A report comparing the performance of various glass types reached the conclusion that “... it could be concluded that in sub tropical and tropical climates single glazing incorporating a tinted or reflective glass with a low-E coating to the inside surface of the glass would be a suitable method of improving the energy performance and comfort within homes.

Recommendations for glazing based on the study are:

- For existing homes use a reflective film with a low-E coating applied to the inside surface of the existing glazing
- For new homes use a laminated solar control glass with a low-E coating applied to the inside surface of the laminated composition.

This ought to optimise the overall cost of the glazing system.”

See Appendix 1.3 for comparative graphs

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Windows

Non–shaded, untreated glass windows are a high heat source for your home.

The heat load through windows can be reduced by

- shading the glass
- selection of glass with special properties,
- the installation of heavy drapes/curtains or
- a combination of these.

Extend your window openings as close as possible to the ceiling level to encourage the venting of hot air which may collect against the ceiling.

Reflective backed curtains reduce some of the heat entering a room. However, once the heat is through the glass and into the room behind the drapes then some or all of this heat will circulate into the room. The drapes also block out any breeze that can provide cooling.

Considerable heat can be transmitted into the room if the windows have metal frames. They conduct heat very well and will radiate heat into the room even after sunset.

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The simple solution is to shade all windows in the first place
The “Low E” glass (ie low emissivity) is a type of insulated glass that increases the energy efficiency of windows by reducing the transfer of heat. The unique properties of Low E coatings allow the glass to retain very high daylight transmission and act as a barrier to the absorbed heat in the glass, reflecting it outside for better solar control.

Using glass which is only tinted will not achieve the same level of benefit. The graphs show there was little difference in the results achieved between using the clear glass and tinted glass. No appreciable temperature difference occurred between outside air temperature and the room temperature when the window was fitted with tinted glass.

Types of Windows
There are five main types of “windows”.
1. Sliding
2. Hopper
3. Casement
4. French and folding doors and
5. Louvres

Careful thought should go into choosing your window type as their effect on your internal environment is important and the cost of changing style at a later date is expensive.

Sliding style windows and sliding doors restrict approximately 50% of the airflow compared to a full opening.

Hopper style windows also impose significant restrictions to airflow for a given sized opening.

COOL MOD TIP
Avoid sliding and hopper type windows
French doors, folding doors, casement windows, and louvres on the other hand have much larger equivalent openable areas.

**Casement Windows**
Side hung casement windows opened towards the direction of the cooling breeze help direct the airflow into the house that might otherwise go past the opening.
Casement windows are the best for “catching” breezes, but like the folding doors they suffer from “security” problems when in the opened position.

**Louver Windows**
Unlike other windows, louvres can be opened on an angle when it is raining and allow breezes to enter whilst restricting the rain.
Louvres can be fitted with relatively unobtrusive bars that provide security for open louvres but do not restrict airflow.
Louvres can achieve the levels of sealing for air-conditioned areas as required by the Building Code of Australia (BCA) for residential windows.

**Bi-fold Door**
Bi-fold doors can be installed to maximise ventilation and access to entertainment areas.
Flyscreens

Flyscreens help control insects but do restrict the airflow. They need to be kept clean as dirty flyscreens can significantly restrict airflow regardless of the window type.

Research\(^7\) revealed that the drop in wind speed because of flyscreens can be significant, in the order of 30+%, depending on flywire type and thread density. Dirty wire can also cause drops in wind speed through the flyscreen in the order of a further 10%. The retractable flyscreen allows for maximum ventilation when insects etc are not present.

Window Frames

The type of materials used in frame construction can seriously change the amount of heat transmitted through the frame into the room, particularly if the frame is exposed to external heat, either directly from the sun or radiated from unlined eaves and verandahs or concrete areas. Ensure that if using metal window frames they do not have a “thermal bridge” effect. This will prevent external heat being transmitted into the room through the frame.

The simple solution is to shade all windows in the first place

This thermal image clearly shows the heat being transmitted through the metal frame and glass.\(^8\)

Whilst the temperature of the wall (in this case a concrete block wall) is 28–30°C, the temperature of the glass and window frame is in excess of 40°C. The upper section of the window may be shaded by the eaves.

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\(^7\) BEDP Environment Design Guide Tec 2, May 2007 page 9 – “Natural ventilation in passive design” by Richard Aynsley

\(^8\) Mabel Measurement of Darwin Houses – Sept 2006 – Dr M Luther, Mobile Architecture and Built Environment Laboratory (MABEL) School of Architecture and Building, Deakin University, Victoria
Design of eaves and verandahs

Having a verandah particularly on the northern side provides a method of shading any exposed walls. Large openings and/or banks of louvres allow the cooler air from under the verandah to be utilised in keeping your home cool. It is however important to ensure the eaves or soffits (sheeted area under the rafters or bottom section of trusses) are lined preferably with a reflective material fitted to reduce the possibility of radiated heat reaching the walls or windows.

The positioning of pot plants/herb and spice gardens/small vegetable gardens or ponds along the verandah provides additional cooling as the plants and water act similarly to the “cool pool”. The verandah has the additional advantage of allowing the windows to be left fully open in all conditions apart from the strongest driving rain.

The “cool pool” is a method adopted in many houses in the Middle East to provide cooling by passing the in-coming air over the water. Some modern units in the suburb of Parap in Darwin have adopted this ancient but simple method to aid cooling.

Floors

The effect of the floor on your home and therefore its treatment is completely dependant on whether you have an elevated or ground level house.

Elevated houses

In the case of an elevated house the floor can be a source of heat during the day, particularly if heat is reflected from concrete under the house on to the underside of the floor. Planting vegetation or hanging awnings can keep the sun off concrete or paved areas. At night the floor will generally follow the ambient temperature and therefore provide some cooling.

This wide verandah provides shading to the walls, allows doors/windows to be left open even in driving rain and the lined soffit protects the walls from radiant heat as well as providing a pleasant outdoor dining and entertaining area.
A significant issue to consider is whether the area above the floor is to be air-conditioned. If so, then the floor can allow unwanted heat into the area in an elevated home, if precautions are not taken. Carpet will provide some form of insulation and sound proofing however care needs to be taken to ensure that condensation does not occur as this can cause premature deterioration of the carpet.

The installation of compressed fibre cement (CFC) sheeting or equivalent or even a polystyrene insulation, will reduce the transfer of heat and sound through the floor.

Ground level houses

In the case of a ground level house the floor is certainly the coolest element in the house during the day and even the night with the temperature rarely exceeding 30°C. The temperature will remain equivalent to the ground temperature and will change only very slowly. Although the floor may be cooler than the ambient temperature during the day it will certainly not cool down overnight and may be hotter than ambient temperature during this time. When carpeted, the floor acts similarly to an elevated house by following the ambient temperature.
Outside

This section deals with outdoor living areas such as the garden, the swimming pool and hard surfaces and how they affect your ongoing costs and the environment. Careful thought and simple planning can make the outside of your house so much more efficient!

Location of air conditioning units

Ensure the external components of your air conditioning units are not installed on the northern or western sides of your home. If they must be installed in this location (for example to reduce the length of refrigerant piping) then ensure they are in well ventilated and shaded areas – such as high up in the protection of the eaves. Some structures are designed and installed to hide the units from view but care must be taken to ensure that they do not actually reduce the rate of air flow around the unit thereby reducing its efficiency and its life because of the need for it to work longer cycles trying to remove the same amounts of heat.

The unit is required to get rid of the heat taken from inside the house; if it is in a hot position then it makes it harder for this to occur. A cooler well ventilated position helps it do its job. Sadly, the air conditioning industry has not listed this requirement in its recommended practises and the numbers of units exposed to direct sunlight for large portions of the day are testament to this lack of forethought and training.

If you are considering using a multi-head type split air conditioner then ensure that the bedrooms and living areas are not combined as their operating requirements (time of use) generally do not coincide. The result of the compressor unit having to operate for much longer periods than would be the case in a better “balanced” system is increased electricity costs and the unit wearing out more quickly.

Note where the air conditioner compressor is planned to be installed.

This position is exposed to the afternoon sun and will result in the unit performing less efficiently.
Water

“We build huge dams, pipe the water enormous distances, purify it all to a potable standard, use it once, put it into another enormous reticulation system, spend huge sums on cleaning it again, then throw it into a river so that somebody else can drink it downstream – then we wonder why we are short of water.

We put all our black and grey waste water into the sewer – then import loads of fertilisers to improve the fertility of our gardens.

We build another reticulated system to carry away the free rain that falls on our roofs – without even using it.”

The above quote is from Derek F Wrigley. Although referring to the situation “down south” his comments also apply to Darwin (with the exception that our waste is only partially treated before being dumped into our harbour).

The average person in Darwin/Palmerston uses almost twice as much water as their counterparts in southern cities. A lot of this water (65%) is used unnecessarily in our gardens (2). We use approximately 470 litres per person per day. This water costs us over $2 million per year to collect, pump and treat and this money could be better used elsewhere instead of providing water to over-water our gardens and wash down our driveways.

The following recommendations can be more easily and cheaply incorporated into a new house design than trying to install them in an existing property at a later date. Some simple forward planning can make the task so much easier.

9 Derek F Wrigley “Climate change needs housing change” published by the Nature and Society forum
Future use of rain and grey water

Make sure that if gutters are installed the future installation of a tank is simplified by ensuring gutters are correctly sloped and the number of downpipes is limited.

Have the necessary planning done and fittings installed during the construction phase to allow you to re-use your grey water either now or in the future. Fittings can be installed that will allow you to connect to them at a later date. Remember that you will most probably have concrete adjacent to your house so the pipes need to be installed before the concrete is laid. This could save considerable cost and effort if you decide to or are required to make use of your grey water in the future.

Your garden

Limit the amount of your garden devoted to lawn. Lawns are notorious water users and unless mown with a hand mower use energy in the continual ongoing mowing requirements. The careful selection of the right lawn for your conditions can also result in the need to water less.

Consider low growing ground cover as an alternative to lawn. Synthetic turf can also provide a year round maintenance free area for high use areas whilst still being permeable to rain. Synthetic turf does however have the disadvantage that it can retain heat in sunny areas, is costly and does not support any living things.

Plant water efficient plants (not necessarily but preferably “native”) to ensure your water use is minimised. Some plants only require water until they are established and can then stay green and shady all year round without any watering.

Information about water-wise plants is available in the PowerWater booklet from the Top End Native Plant Society, www.topendnativeplants.org.au or Greening Australia NT, www.greeningaustralia.org.au

Selection of the right plants and careful planning of your garden can result in significant energy savings for your home.

Plant lower clumping type trees and shrubs nearer your home, as they provide a “cool” environment and can develop their own micro climate systems generating their own breezes. Leaves and palm fronds can be seen moving even when there is no noticeable breeze in such environments. Do not plant immediately in front of windows and openings as you may restrict prevailing breezes.

Use taller/larger trees to shade your east and west walls from direct sun, be careful when planting tall trees on your northern side as they may eventually shade solar panels installed on the roof.

This shady nature strip was only watered for its first 2 years whilst it was being established

10 PowerWater Corporation and Nursery and Garden Industry NT “How to create a Water Wise Garden in the Top End”
Garden reticulation systems

Plan your garden reticulation system with a number of zones and place plants of similar watering regimes together. This will enable you to provide the amount of water necessary for those plants and thereby limit any wastage through over-watering.

Concreted areas

Limit the areas to be concreted or paved. Concrete causes three main problems,

1. It can reflect heat onto the walls and windows of your home.
2. It acts as a heat sink releasing heat into the surrounds long after the sun has gone down. Breezes that pass over heat sinks can be very hot compared to breezes that come from shaded areas.
3. It reduces the amount of rain that soaks into the soil and tends to direct the water to waste very quickly thereby overloading the stormwater systems.

Light coloured concrete can reflect a lot of heat onto your house whilst dark coloured paving or asphalt can act as a heat sink, radiating heat into adjacent materials and zones long after dark. Consider the use of ground cover such as wood chips, permeable paving and light coloured pebbles or crushed rock.

Swimming pools and spas

Plan for the future installation of a pool or spa when designing your house. Important considerations are size and quantity of water, location, fencing and surrounding surfaces and vegetation.

What size?

The more water you need to fill your pool the more money you will be spending on power and chemicals, not to mention cleaning! Think about the size and depth of your spa, plunge pool or larger pool. The larger the surface area the more water evaporation you will experience and the more top up water you will need. Sun and wind can lead to very high evaporation levels in the Top End. Deeper water will stay colder than shallow pools.

To help plan the size of the spa or pool think about how many people will be in the water at once and what activities they will be doing. Remember, it’s like a house, the bigger it is the more work it is to keep clean!

Where to place my spa or pool?

Pools require safety fences so plan the access points and fences to fit in with the house and garden features. If your water is in shade it will remain colder and evaporate less than if in a sunny and windy position.

Surrounds

When designing the area around the pool, avoid dark coloured surfaces that become too hot to walk on if they are in the sun. Think about flowers, buds, seeds, leaves and palm fronds dropping into the pool when selecting vegetation. Avoid fine leaf plants as these leaves tend to drop to the bottom rather than floating into your skimmer box.

If you choose a salt water pool, avoid sensitive plants that cannot tolerate splashes of salt water.

COOL MOD TIP

Install a Viron pump and a pool cover and you are well on your way to cheaper swimming.
Once you have considered the above and have decided to proceed, then the following suggestions are recommended to minimise both your ongoing costs and your further impact on the environment.

1. Ensure the pump motor is a high efficiency one to enable you to achieve power savings from the outset. Often pools are provided with inefficient motors and although cheaper initially, over a five year period will cost you approximately $2,000 more to run (Appendix 4.1). A pump can generate more than 7 tonnes of greenhouse emissions based on 5 hours per day operation during that period. Have your pool provider do an economic comparison over a five year period (including initial costs) of the motor they propose compared to installing a more efficient unit.

The Viron pump, which makes use of technology developed in the NT, can save approximately 70% in energy consumption and is significantly quieter than other pumps. This enables you to install the unit closer to the house and possibly reduce pumping distances thereby providing further savings. Based on the 5 hours operation suggested above, the Viron pump will save you approximately $290 per year (Appendix 4.2) and the environment 1 tonne of greenhouse gas emissions. That equates to more than $1,000 and nearly 6 tonnes of emissions over the 5 year comparison period!

For more information on the Viron pump visit www.coolmob.org.

2. Limit the width of your pool to 5 metres and have a fairly regular shape which will make the selection of a pool cover easier and most probably cheaper.

Pool covers are recommended to reduce the amount of top up water needed, and time operating the filter and the chlorinator. In turn, this will save energy costs and pollution, and/or reduce the amount of chemicals needed to maintain water quality.

The pool cover for an average size pool will pay for itself in approximately three years (Appendix 4.3) as well as significantly reducing the carbon footprint of your swimming pool (more than 1 tonne of greenhouse emissions over that period) and saving you a lot of work in keeping the pool clean.

3. Do not install an automatic top up system as if they malfunction considerable water can go to waste without you being aware. It is better if you do your own topping-up as required and measure the amounts of water used by reading your meters before and after refilling. This helps to clearly show the benefit of having a pool cover.

4. Use at least 50mm piping between your pool and pump and keep it simple. The inlet and outlet pipe diameters, the length of piping, the use of elbows and complications in the run, type and quantity of jets all affect the back pressure and therefore operating costs of the system.

Thousands of litres of water per year are saved by using a pool cover and they also reduce the amount of dirt/leaves etc getting into your pool.
Inside

In this section, information is given on the importance of the type of paints and materials which will provide a healthy environment for your family as well as the importance of selecting the right appliances. Appliances, once installed will have a long-term effect on your ongoing running costs and consequently influence the effect your lifestyle has on the environment. Ensure the builder provides the right appliances and fittings for you to give you a good start.

Hot water

The selection of the hot water system for your home is a decision that will have a significant impact on your ongoing costs. A higher up front cost will provide savings in the long run if you choose a solar hot water system instead of the initially cheaper electric or gas unit.

The actual annual cost to operate an electric storage heater is difficult to ascertain because the cost depends so much on the usage habits of the individuals involved. Power suppliers estimate that for an average family of 4 it is in the range of $500 to $600 per year. This will equate to more than $7,500 over 10 years and more than 19 tonnes of greenhouse gases. (Appendix 5.1).

If you are restricted from putting a solar hot water unit (SHW) tank on the roof of your home then do not allow it to deter you from proceeding with the solar option. Installing the tank at ground level with a recirculating pump moving the water from the tank up to the solar panels installed on the roof is a much better option than using an electric or gas heater. The amount of power used by a recirculating type pump is minimal and would have negligible effect on the above calculation.

When installing the unit on your roof have it located it in a good position for solar collection but avoid the middle of the area as this will inhibit the installation of PV panels at a later date. So often, the SHW unit, supplied with a new house during construction is the first panel on the roof and generally takes a central position thereby restricting future options.

Consideration should also be given when locating your SHW unit that it is near the area which uses small quantities of hot water more frequently – for example the kitchen. By doing this you reduce the amount of water wasted whilst waiting for the water to come through the tap.

COOLMOD TIP
Position your SHW unit to allow installation of PV panels at a later date.
Plumbing

Ensure all plumbing fittings are 4 star (minimum) WELS (Water Efficiency Labelling) and all taps are fitted with aerators. A 4 star toilet cistern will use approximately 50% less water than an unrated unit. Your plumbing fixtures will last a long time so ensure you have the best standard of water efficiency.

You can save money on plumbing by choosing a plan that groups wet areas like kitchens, laundry and bathroom close together. The modern trend towards multiple bathrooms makes this difficult to achieve. The wastage and increased costs caused by the spreading services over a greater area, plus the extra ongoing costs and cleaning are good reasons to give serious consideration to how many bathrooms are necessary for your home.

Appliances

When negotiating fixtures and fittings for your home, ensure you are going to be provided with appliances that have high energy star ratings. Buying energy efficient appliances can save you money on your bills and reduce your environmental impact without making a difference to your lifestyle.

The actual appliance model and its star rating should be specified by the builder/developer and it’s important when selecting the units that the cost of operating the unit is considered. In some cases some units can cost as much to run over a 5 year period as they do to purchase, so it is important to do your homework.

To make a quick comparison of appliances, the number of kilowatt hours (kWh) shown on the star rating label can simply be called dollars based on 20cents per kWh over a 5 year period.

Ceiling fans

Ceiling fans are an essential part of living in the tropics and are necessary whether the home is air conditioned or not. If your home has air conditioning, operating your fans (ceiling or free standing) will enable you to operate your air conditioner at a higher temperature setting and still achieve comfortable conditions. This will also save you power.

It is important that ceiling fans are not set too high in areas with high ceilings as this severely reduces the effectiveness of the fans. Fans set too high will distribute the hot air trapped against the ceiling around the room.

Keeping fans clean is important; a dirty fan uses more power because of the extra drag on the blades. For this reason, the stainless steel blade units are preferable as they tend not to deteriorate as quickly as painted blades. Painted blades tend to collect dust when the paint starts deteriorating, especially on the leading edges.

COOL TIP

Having windows that open to ventilate bathrooms and laundries is cheaper and quieter than relying on an exhaust fan. Your rooms will have a light airy feel and you’ll save on electricity.
Fans fitted with a variable speed control and off switch are more convenient than those with a 3 speed controller. The variable speed control allows much better control and the simpler turning off action may encourage the turning off of fans when leaving a room. Remember to always switch fans off when a room is not in use, as this will save energy use and costs.

**Air conditioning**

Air conditioning is often used to achieve comfortable sleeping conditions by lowering temperatures and humidity. The number of operating hours required for air conditioning to achieve thermal comfort can be substantially reduced (or eliminated) by careful design of new homes, alterations and additions.

**Paints**

Regular paints give off low level toxic fumes that can cause breathing irritations and headaches.

Most paints contain some toxic chemicals which can be harmful, most commonly volatile organic compounds (VOCs). These are the toxic fumes emitted from most synthetic–based paints and make up the new paint smell that many people find unpleasant. VOCs can be harmful to people and the environment in the manufacturing process and during and after application.

VOCs can continue to seep out in small amounts for years after painting and can lead to many health problems. It takes years for them to completely disappear and often, by then its time to repaint. The smell is not a major problem in new house construction as most of the smell has dissipated by the time you move into your completed house. However, it may be more of an issue when renovating an occupied home.

“Green paints” are defined by their lack or low level of VOCs. “Green paints” can be either environmentally friendly natural paints or environmentally friendly synthetic paints. On the whole natural paints are a little more environmentally friendly in their manufacture and disposal than synthetic paints. However synthetic paints are generally a little less expensive, a little more durable, and come in a wider range of colours. Both are non–toxic and have zero or very low VOC level.

It is therefore important when planning a new home or renovations that consideration be given to the type of paint used particularly if members of your family have respiratory symptoms, allergies, chemical sensitivities and particularly for pregnant women and young children.

These paints generally cost more, however the environmental gains should be taken into account when doing the evaluation. Consider the application rates, number of coats required, durability etc as well as the base cost of the material when comparing costs.

**COOL TIP**

If you plan on installing and using air conditioning make sure the areas are well insulated and sealed to ensure efficient use of the air conditioning.
Kitchens

A well designed, efficiently equipped, functional kitchen can add real value to your home.

Layout of kitchens

A good kitchen gives you room to move but is compact enough to allow easy reach between different activities, like preparing food, cooking and rinsing. It is a good idea to leave generous bench space between the sink and the hotplates as this tends to be the most useful space for food preparation.

Locate dishwashers close to sinks to allow easy loading: this also concentrates your plumbing requirements in one place.

Position refrigerators and freezers away from stoves/ovens and external walls exposed to direct sunlight. Ensure refrigerators and freezers are well ventilated. The efficiency of these appliances depends on their ability to remove heat and if ventilation is restricted then their efficiency decreases. If the unit is enclosed then provide additional ventilation into the ceiling space. Ensure sufficient space is allowed around the unit in accordance with the manufacturer’s recommendation.

Multi-bin sorters under/near kitchen sinks are a great idea to sort your rubbish for recycling straight away.

Remember, a lot of heat is generated in the kitchen and a lot of time is spent in this room so it is important to ensure it is well ventilated and has as much natural light as possible.

Kitchen equipment

The selection of the equipment that is most efficient, cheapest to run and best for the environment at the time of equipping your home may result in an increase in the overall cost of your kitchen but you will certainly reap the benefits over the life of the appliance. To change a less efficient appliance later could mean a significant cost. Carefully select what is best suited for you, not what is just generally supplied by the builder. To change a less efficient appliance later could cost you dearly.

Choosing the right size for your needs is also very important. A big 4 star refrigerator uses more energy than a smaller 4 star refrigerator.

You can choose either a single unit such as a gas or electric stove, or a combination of gas and electric separate hot plates and oven.

Coolmob TIP

If for example, an appliance uses 400kWh per year to run, this equates to $400 to run for 5 years. The price of power is already above the 20 cent mark per unit and will certainly increase over the nominal 5 years period of the calculation but this does work as a quick way of comparing appliances.

Any savings in operating costs is also a saving for the environment.
**Hotplates**

Gas hotplates are generally cheaper to use, respond rapidly, are easy to adjust, provide good temperature control and importantly produce less greenhouse emissions.

Of the electric options the following chart\(^\text{11}\) compares the various types:

<table>
<thead>
<tr>
<th>Type of electric hotplates</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil</td>
<td>55 – 65</td>
</tr>
<tr>
<td>Solid</td>
<td>50 – 55</td>
</tr>
<tr>
<td>Ceramic – Standard</td>
<td>55 – 60</td>
</tr>
<tr>
<td>Ceramic – Halogen</td>
<td>45 – 50</td>
</tr>
<tr>
<td>Ceramic – Induction</td>
<td>80 – 85</td>
</tr>
</tbody>
</table>

Ceramic cooktops have the elements concealed under a flat glass surface providing a stylish appearance, are easier to clean than coil and solid hotplates however they are less efficient, have a slower response time and are generally more expensive.

---

**Ovens**

For your new oven, look for energy efficient fan–forced models with triple glazing and a high standard of insulation. Fan–forced ovens heat more quickly than conventional ovens, can cook food at lower temperatures, and use up to 35% less energy than conventional ovens.

Gas ovens, although they will heat to a given temperature much faster than an electric oven require ventilation and lose considerably more heat than electric units, thus heating up your kitchen and home.

**Microwave ovens**

Microwave ovens can be extremely energy efficient as a result of the short cooking times involved. The energy used is generally used to heat the food only, with little wasted in heating cooking utensils or the oven itself. The resultant shorter cooking times means less energy consumption than conventional ovens.

**B–B–Q**

The final option to consider is the B–B–Q. Incorporate an external space for one in the design of your home and if installing gas then have the reticulation extended to allow the unit to be connected. This avoids the need to refill smaller gas bottles. A B–B–Que has the obvious advantage of ensuring that cooking does not heat up the kitchen.

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Lighting
There are a number of basic rules to consider when choosing lighting.

• Don’t over-light your home. Avoid the tendency to provide unnecessarily high levels of lighting, especially when using downlights

• Use only fluorescent, compact fluorescent or LED lamps

• Make sure the number of fittings turned on by one switch is limited so that you have much better control over how many lights you are turning on at any one time. More lights than you need on the one switch can be very wasteful

• Home designers/decorators often install more fittings than necessary and could achieve adequate lighting levels and gain the same effect by using other types of fittings and lamps.

Remember that low voltage does not mean low energy so when comparing different types of lamps compare “wattages”. A 12 volt 50 watt lamp (excluding transformer) uses the same power as a 240 volt 50 watt lamp. Incandescent and halogen lamps only convert a small amount of their energy into light; the majority is converted into heat, just what we don’t want in the tropics. These lamps can become hot and uncomfortable to sit under.

Power Points
Avoid the tendency to install power points where they won’t be seen behind appliances, as you want to be able to reach them easily to turn the units off to reduce stand-by power. This particularly applies to home entertainment equipment and, in the kitchen, the microwave.
Why This Book Was Written

In his paper “Climate change needs housing change” Derek F Wrigley highlights the need to be critical about contemporary housing design practices.

“...there is insufficient constructive criticism about architecture these days and consequently we never seem to learn from our mistakes. The effective use of natural resources is a critical environmental science and should be open for healthy, informative public debate, so hopefully these comments can be useful.

Otherwise, how will we ever learn and improve? The results of ‘no criticism’ can be seen anywhere around the suburbs of Australia and regrettably the housing industry has shown itself to be a slow learner.

There is an urgent need for rational voices to be raised in this debate. When are the opinions of concerned house buyers ever heard – where is their forum? It has been too one-sided for too long, as this booklet reveals. If you have something to say about housing standards, let your voice be heard, otherwise the status quo will only continue.”

This booklet includes drawings and composite pictures of residences (some new houses, just completed or not fully completed) that will have problems and high associated energy use for many years.

Some of the houses depicted would be extremely expensive and while the owners may be in a position to comfortably pay for the additional energy they use, it should be acknowledged that the wasteful use of energy contributes to the current detrimental impact of humans on our environment.

× Dark coloured roof and walls
× Lack of shading on northern elevation
× High heat load transfer through walls due to lack of shading
× Limited window size
× Lack of garden depth to provide shading
× Complex roof structure for future solar and water collection

× Complex roof structure with negligible space for solar collection
× Large numbers of downpipes drastically limiting your ability to collect rain water
× Air conditioner compressors exposed to direct sunlight
× Heavy construction (blockwork) exposed to sun
Dark coloured heat absorbing walls
Air conditioner compressors exposed to direct sun
Small and limited number of windows
Complex roof design
Complex roof structure with a number of downpipes limiting water collection

Large expanse of unshaded “heavy construction” exposed to direct afternoon sun
Air conditioner compressors exposed to direct sun
Very limited cross-flow ventilation
No attempt or space to use vegetation to provide shading

The COOLmob problem and solution

The photograph above illustrates a house which is supposedly designed for a Mediterranean climate. For all the reasons listed in the previous examples it is unsuitable for the tropical conditions in Darwin.

Housing being constructed today will be with us for around 30 years. The damage to the environment caused as a result of poor design and construction (such as higher consumption of energy and the associated demand on natural resources) keeps increasing with time, with every unsuitable new house built. Moreover it does nothing to make home ownership more affordable for ordinary people.

We already have the knowledge and the tools to build housing which is suited to Darwin’s climate. We can make easy changes at a personal and community level now to have a positive environmental impact in the future. These changes will also save us money without having to compromise living standards.
Appendix

1.1 Household comparison system

The chart was based on the audits completed by COOLmob in Darwin 2002–04

1.2 Estimated expenditure on power over next 10 years

<table>
<thead>
<tr>
<th>Per Quarter</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>$300</td>
<td>$1,200</td>
<td>$1,284</td>
<td>$1,374</td>
<td>$1,470</td>
<td>$1,573</td>
<td>$1,683</td>
</tr>
<tr>
<td>$1,100</td>
<td>$4,000</td>
<td>$4,280</td>
<td>$4,580</td>
<td>$4,900</td>
<td>$5,243</td>
<td>$5,610</td>
</tr>
<tr>
<td>$1,600</td>
<td>$6,400</td>
<td>$6,848</td>
<td>$7,327</td>
<td>$7,840</td>
<td>$8,389</td>
<td>$8,976</td>
</tr>
<tr>
<td>2016</td>
<td>$1,801</td>
<td>$1,927</td>
<td>$2,062</td>
<td>$2,206</td>
<td>$2,361</td>
<td>$17,740</td>
</tr>
<tr>
<td>2017</td>
<td>$6,003</td>
<td>$6,423</td>
<td>$6,873</td>
<td>$7,354</td>
<td>$7,869</td>
<td>$59,134</td>
</tr>
<tr>
<td>2018</td>
<td>$9,605</td>
<td>$10,277</td>
<td>$10,996</td>
<td>$11,766</td>
<td>$12,590</td>
<td>$94,615</td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$17,740</td>
<td>$59,134</td>
<td>$94,615</td>
<td>$17,740</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The base cost used in this calculation is assessed from households achieving 10, 5 and 2 stars respectively on the COOLmob Energy rating system^{12}.

^{12} The cost of energy has been increased at an annual rate of 7% to allow some inclusion for the expected increase in energy costs. This calculation however does not include any allowance for a “carbon” or equivalent tax being imposed which would significantly increase the costs calculated.
1.3 Performances of different glass types

Only very minor benefit is gained by using tinted glass
The benefit of the clear glass with Low E film is clearly shown. However, the laminate glass with Low E differential achieved the best results.
# 4 Swimming Pools

## 4.1 Standard Pump

Power used and greenhouse gases produced by a 1kW pool pump over a 5 year period

<table>
<thead>
<tr>
<th>Pump rating kW</th>
<th>Run hours per day</th>
<th>kWh per week</th>
<th>kWh per year</th>
<th>$ per year</th>
<th>kg CO2 per year</th>
<th>kg CO2 over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>35</td>
<td>1820</td>
<td>400.4</td>
<td>1437.8</td>
<td>7,189 (7 tonnes)</td>
</tr>
<tr>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td>2015</td>
<td>Total</td>
<td>$400 $428 $458 $490 $524 $2,300</td>
</tr>
</tbody>
</table>

## 4.2 Viron Pump

Power and greenhouse gases saved by using a Viron pool pump over a 5 year period

<table>
<thead>
<tr>
<th>Year</th>
<th>Total $ over 5 years</th>
<th>kg CO2 over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>$290</td>
<td>5,989 (6 tonnes)</td>
</tr>
<tr>
<td>2012</td>
<td>$310</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>$332</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>$355</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>$380</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$1,668</td>
<td></td>
</tr>
</tbody>
</table>

13 The cost of energy has been increased at an annual rate of 7% to allow some inclusion for the expected increase in energy costs. This calculation however does not include any allowance for a “carbon” or equivalent tax being imposed which would significantly increase the costs calculated.
4.3 Pool Covers

Based on using the pool cover for 3 months each year. Increase use of the cover increases the savings.

<table>
<thead>
<tr>
<th>Operating costs over 3 years</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>$1,286</td>
</tr>
<tr>
<td>Not filtering for 3 months per year</td>
<td>$321</td>
</tr>
<tr>
<td>Chemicals $30 per month</td>
<td>$1080</td>
</tr>
<tr>
<td>Reduced chemical requirements</td>
<td>$270</td>
</tr>
<tr>
<td>Water 1.5kL per fortnight to top-up</td>
<td>$42</td>
</tr>
<tr>
<td>No water loss for 3 months per year</td>
<td>$11</td>
</tr>
<tr>
<td>Total</td>
<td>$602</td>
</tr>
</tbody>
</table>

5 Solar Hot Water Units

Power used and greenhouse gases produced by an electric hot water service over a 10 year period

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>kg CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$550</td>
<td>$589</td>
<td>$630</td>
<td>$674</td>
<td>$721</td>
<td>1,975 per year</td>
</tr>
<tr>
<td></td>
<td>$771</td>
<td>$825</td>
<td>$883</td>
<td>$945</td>
<td>$1,011</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$7,599</td>
<td>19,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(19 tonnes)</td>
<td></td>
</tr>
</tbody>
</table>