

Cool roofs versus dark roofs: special report



Is it time to mandate white roofs in the residential context?

Cameron Jewell | 13 March 2014

SPECIAL REPORT: We talk to manufacturers and sustainability expert Dr Chris Reardon; we check the councils such as Pittwater and Woollahra to see why they don't like light roofs; take a look at City of Melbourne's study; and even the argument for dark roofs.

It started with an article on a study out of Berkeley Lab in California, which concluded that white roofs outperformed black roofs economically as well as environmentally. It called for the phasing out of dark roofs in hot climates, especially those prone to heatwaves. This would save energy costs, protect against the urban heat island effect and tackle climate change.

- See our article [Study: white roofs reign supreme](#)

Sounds like a no-brainer. However, the article provoked much debate among *The Fifth Estate* readers, with some saying black roofs would make meeting updated BASIX heating requirements easier in mild climates – and to expect an influx in NSW – others saying black roofs were little more than a sorry trend, and even a US lobby group warning against phasing out black roofs in hot climates.

And with black and dark tiles accounting for the vast majority of the big suppliers' sales, the trend for black roofs shows no sign of stopping in Australia.

So perhaps it's not such a straightforward matter. We decided to speak to a range of stakeholders to see their position on black roofs, and to see if we could find a definitive answer.

THE MANUFACTURERS

Monier

The product range of the major tile companies in Australia may give an indication as to why there is a such a high proportion of black roofs in Australia.

Monier's website gives an indication of the BASIX classification for their roof tiles, which is split into ratings of light, medium or dark, depending on the tile's solar absorptance (a measure of the percentage of incident solar radiation absorbed).

Out of 22 concrete tile colours, only one was classified as light and four as medium. For terracotta tiles, out of the 17 choices none were light and only five were rated medium.

On its website Monier says: "Light coloured roof tiles keep cooler than darker coloured roof tiles and this cooler temperature can mean reduced energy costs for cooling a home or building."

A spokeswoman for Monier told *The Fifth Estate* that the company had "a fantastic range" of light-coloured tiles, however customer preference was heavily skewed towards dark tiles.

In fact, demand for dark tiles dwarfed medium and light ones. In NSW, she said, 70 per cent of tile sales were black or grey and a similar result could be found for Victoria. "Wild rice" was the top-selling light-coloured tile, and this only accounted for three per cent of sales volume.



The trend for black roof houses shows no sign of abating in Australia.

Even in Queensland, where lighter-coloured roofs were most popular, the biggest selling Monier tiles were "Barramundi" (dark grey) and "Sambucca" (black).

In NSW, 70 per cent of tile sales are black or grey and a similar result can be found for Victoria.

The spokeswoman noted, however, that BASIX categorisation of tiles was not based on a visual assessment [though light-coloured roofs typically have lower solar absorptance] and treatments could be added to darker tiles to reduce solar absorptance.

"In some cases the added cost of a reflective coating [to reduce solar absorptance] would make a product too expensive for some customers."

The spokeswoman also said that building scientists who were part of parent company CSR said that colour did not make a significant difference to thermal performance of a house because roof insulation formed a thermal barrier.

It was Monier's opinion that everyone should insulate their home, she said.

“The part colour plays here is that a dark roof in certain climates may mean that [Building Code of Australia] compliance would recommend a slightly higher R-value for their insulation, but it is not a massive factor.

Boral

Another major player, Boral, fared no better than Monier in its offering.

Out of Boral’s 37 shades of roof tile, just one was classified as white, with 11 medium and the remaining 25 dark.

In an insights brochure, Boral, however, stated it was “seeing a move towards lighter colours that blend with the natural environment”.

“Research shows that light coloured roof tiles can lower the air temperature in the roof space by up to nine degrees compared to dark tiles.”

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Roof Tile Association of Australia

The Roof Tile Association of Australia did not respond to requests for information on its position, however the RTAA website says:

“Dark colours are believed to attract greater heat but the difference in heat to a light coloured roof is thought to be minimal. Light coloured roofs have been thought to reflect more heat away from the home based on rating systems such as BASIX. However there is no reason a dark roof cannot perform similarly with simple inclusions such as sarking, insulation and ventilation.

“In many cases research does suggest that a dark roof could attract heat, however this has not been conclusively proven and other factors such as house orientation, use of ventilation/insulation and use of passive design principles will have greater bearing on whether the house is hotter in the warmer months.”

However, research the RTAA commissioned, performed by the University of Newcastle, found that light coloured tiles yielded “energy savings between 25-36 per cent compared to dark coloured tiles”.

Lower cooling energy demand was found even with insulation or sarking, though the research again noted that “absolute energy saving is small compared to other conservation strategies”.

Steel alternatives

BlueScope Steel has been promoting cooler roof products, and spoke to *The Fifth Estate* in 2012 on the launch of their CoolMax product.

- See our article [Bluescope and the roof movement: white is the new black](#)

The product boasts reduced annual cooling energy costs of commercial and office buildings by up to 7.5 per cent compared to other colours.

Bluescope's then sustainability manager Richard Rowe said there was a layer of benefits to a cool roof – from spending less on airconditioning and keeping outside temperatures down, which helped avoid the urban heat island effect.

SUSTAINABILITY EXPERT DR CHRIS REARDON

The recently released sustainability guide [Your Home 5th edition](#) states that light coloured roofs are estimated to reflect up to 70 per cent of summer heat gain – around 50 per cent more than a dark roof.

Dr Chris Reardon, principal author of the *Your Home* guide, told *The Fifth Estate* that, at the end of the day, in the Australian context, white roofs were better than black roofs, but that it was climate dependent.

He said the manufacturers were technically correct in saying that a darker colour could be overcome through insulation.

"In cooling-dominated climates, you need a bit more than one layer of sarking – two layers separated by 25 mm gap plus bulk insulation," he said.

However, the extra insulation requirements would incur an additional cost on builders, likely to be passed on to buyers.

"The bottom line is that if they're going to argue that darker roofs are okay, it should be mandatory to put in a double layer of sarking," Dr Reardon said. "But why create a problem in the first place?"

He did note, however, that a dark roof could be beneficial in colder, heating-dominated climates like Canberra and possibly even Melbourne, but that it shouldn't even be a consideration north of Brisbane.

Look to the future

Dr Reardon warned that when designing houses, instead of taking into account current climates it would be prudent to look at projected temperatures over the 50-80 year lifetime of a house, with CSIRO research predicting temperatures up to 4°C warmer on average by 2100.

Many thermal rating tools, such as those used to assess NatHERS ratings, were working off historical climate data, meaning that houses built now might not be prepared for the climate change affected temperatures of the future.

"It's only going to become more problematic," Dr Reardon said.



Dr Chris Reardon

“House rating systems don’t penalise roof colour as much as they should.”

He “very much” agreed with the call to ban black roofs in heatwave-prone areas, as suggested by Dr Arthur Rosenfeld, a Berkeley Lab distinguished scientist emeritus and former commissioner of the California Energy Commission who noted that living on the top floor of an apartment with a black roof was a major risk factor for mortality during Chicago’s 1995 heatwave.

Think of the externalities: the urban heat island effect

With the focus on individual house performance, externalities associated with black roofs are often overlooked, the urban heat island effect being one of the most significant.

A recent study published in the *Proceedings of the National Academy of Sciences* found that in the absence of adaptive urban design, and separate from climate change, urban expansion was going to increase average temperatures by 1-2°C across large swathes of America.

Cool roofs can counteract rising temperatures due to urban sprawl and also greenhouse-gas driven climate change

The study found that cool and green roofs could not only counteract rising temperatures due to increasing urban sprawl, but also offset a significant portion of anticipated greenhouse gas-driven warming.

The Fremantle Doctor

Dr Reardon noted a recent trip to Perth, where he said the “Fremantle Doctor”, a cooling afternoon sea breeze, got 1°C hotter every kilometre it travelled inland thanks to the urban heat island effect.

He said that during his trip there was speculation that during heatwaves the figure was more like 1.5°C, meaning that, in the context of hotter summers and a greater frequency of heatwaves, houses that were maintaining their thermal comfort might soon not have that luxury.

It was increasingly important, therefore, to tackle issues of urban heat islands, he said.

Context is key

The PNAS report, however, found different tradeoffs between regions, leading to the crux of the matter: there needs to be geographically appropriate solutions.

It found that winter temperatures could become cooler if white roofs were installed across the region, causing an increased need for heating that could outweigh reduced cooling, though most regions did still see an overall energy savings by installing cool roofs.

It showed that for heating-dominated climates, white roofs may not be an appropriate solution and that tradeoffs needed to be examined.

“We find that geography and season matters. Adaptations that work at location A might not be feasible for location B,” said lead author of the PNAS study Matei Georgescu, assistant professor at Arizona State University.

COUNCILS: A STICKING POINT?

Sources told *The Fifth Estate* councils could be a real sticking point, with Woollahra and Pittwater councils in Sydney singled out as being notorious for opposing developments with lighter roof colours.

Woollahra Council told *The Fifth Estate* it did not prohibit or generally oppose white roofs, however there were two common issues – heritage and glare.

“White roofs would generally be incongruous with heritage items and are likely to be incongruous with the character of Council’s heritage conservation areas because they would be in stark contrast to the overall character of those areas,” a council spokesman said.

“Development controls in such areas require Council to have regard for the colour and finishes of materials, assessing each case on its merits. In some cases a white roof may be acceptable as part of a contemporary in-fill design.

“White or light coloured roofs are also very reflective in nature, and given the undulating landscape in the Woollahra area it is necessary to consider the impact light reflected from a white roof would have on neighbouring properties overlooking the roof when considering any application.”

Pittwater: aesthetics trumps sustainability

Pittwater in Sydney’s north took a particularly hardline stance against white roofs.

Andrew Pigott, manager planning and assessment at Pittwater, told *The Fifth Estate* that the general rationale behind restricting white and light coloured roofs was “to ensure the built form is non-obtrusive and complements the surrounding natural environment and vegetation”.

“Dark and earthy tones/colours are recessive and blend into the natural environment,” Mr Pigott said. “These colours become subservient and recede into the surrounding natural vegetation and landscape in which they are sited, thus reducing the visual prominence of the built form.”

However, he did say that, due to their reflective nature, lighter coloured roofs had “the potential for glare-associated issues, which contributes to nuisance issues between neighbours”.

BASIX, however, suggests that while lighter colour roofs will reflect more heat (lower solar absorptance), they will not necessarily produce more glare or light reflection.

“It is possible to get a roof with low solar absorptance AND low light reflection,” the BASIX website says.

“It is possible to get a roof with low solar absorptance and low light reflection.”

Pittwater 21 Development Control Plan Part D is the culprit allowing Pittwater to restrict light or white roofs, with the development provisions being:

- the development enhances the visual quality and identity of the streetscape
- to provide attractive building facades which establish identity and contribute to the

streetscape

- to ensure building colours and materials compliments and enhances the visual character of its location within the natural landscapes of Pittwater
- the colours and materials of the development harmonise with the natural environment
- the visual prominence of the development is minimised
- damage to existing native vegetation and habitat is minimised

CURRENT STANDARDS

The Building Code of Australia

The Building Code of Australia (BCA) classifies roof colour based on solar absorptance – the inverse of reflectance – expressed as a ratio between 0 and 1. Solar absorptance values are based on as-new/unweathered product. A value of 0 indicates that a roof absorbs none of the incoming solar radiation, whereas a value of 1 would mean that a roof absorbs 100 per cent of the incoming radiation. Three classes have been established: solar absorptance of less than 0.35; solar absorptance of between 0.35-0.55; and solar absorptance of more than 0.55.

The BCA requires a solar absorptance not more than 0.55 for flat roofs in Climate Zones 1, 2 and 3 (the top half of Australia), however roofs that provide adequate levels of insulation do not have to meet solar absorptance standards.

BASIX

In NSW, BASIX has three categories for roofing colour based on solar absorptance. A light roof is one with a solar absorptance under 0.475; a medium roof is between 0.475 and 0.7; and a dark roof is more than 0.7.

Roofs with lower solar absorptance can help to meet BASIX thermal comfort requirements for cooling.

Tracey Cools, managing director of consultancy **Efficient Living**, however, said that the recent announcement of updated thermal comfort targets in BASIX could have a perverse outcome, with greater use of black roofs and walls.

“I have seen many assessors’ solutions to reaching the new very stringent heating caps is to use dark walls and/or a dark roof for a Sydney climate,” she said.

“Summer cooling targets are generally very easily achieved but the real challenge is winter heating loads.”

“Summer cooling targets are generally very easily achieved but the real challenge is winter heating loads.”

She said she expected an influx of dark colours for NSW areas with moderate climates, though this was not a good outcome for the built environment.

See our articles:

- [Critique of BASIX review hits the mainstream](#)
- [Getting the BASIX right in NSW will bring economic rewards](#)

PROGRESSIVE GOVERNMENT ACTION

Government action on cool roofs has focused mainly on the commercial sector.

South Australia

The Government of South Australia introduced a cool roof requirement for commercial buildings based on a discussion paper released in 2010.

It mandated the use of cool roofs on new or refurbished commercial buildings, and was implemented in the BCA from 2012. Roofs of airconditioned commercial buildings that are constructed new or refurbished on the basis of a development approval now need an upper surface solar absorptance value of no more than 0.4.

South Australia has mandated the use of cool roofs on new or refurbished commercial buildings.

It noted a number of benefits, including reduced cooling loads, reduced peak energy demands, reduction in greenhouse gas emissions and increasing comfort of non-airconditioned buildings.

Melbourne

A [University of Melbourne report](#) on cool roofs commissioned by the City of Melbourne found that there were multiple benefits, including:

- reducing utility bills associated with airconditioning due to lower use lower maintenance requirements for the airconditioning system
- increasing occupant comfort and potential to avoid installing an airconditioner where not already installed
- decreasing the size and prolonging the life of airconditioning system
- lowering roof maintenance costs and extending roof life, avoiding reroofing costs and reducing solid waste
- assisting building in meeting building codes – Section J
- mitigating the urban heat island effect

For residential settings, there was little effect of a cool roof on heating or cooling costs due to high levels of insulation, however there was a benefit for commercial buildings.

The City of Melbourne now provides a [cool roof guide](#) for commercial applications.

THE CASE AGAINST

The EPDM (ethylene propylene diene monomer) Roofing Association, which represents manufacturers of a rubber roofing membrane, has been a vocal critic of white roofs and regulation against black roofs.

They have quoted a study published by Stanford University in 2011 that contradicts the findings of the later PNAS research.

The study, published in the *Journal of Climate*, found that if all roofs across the world were changed to white roofs, while temperatures would reduce in urban areas marginally, they would cause more overall global warming because the cooling of cities could reduce cloud formation.

The study did not take into account reductions in energy use, however – only the change in solar reflection.

The study gained widespread media attention, though according to *Scientific American*, the analysis has been disputed, with one Stanford researcher “highly sceptical that [local cooling creating global warming] would be a common occurrence”.

Saying this, the ERA’s main argument is a valid one: white roofs are not a universal solution. And they do note potential problems: risks associated with increased condensation, potential increased maintenance costs, and the potential to cause increased energy use in heating-dominant climates.

There are potential problems to do with increased condensation, the potential for increased maintenance costs and increased energy use in heating-dominant climates.

However, the ERA is still against the proposal to ban black roofs in warm climates.

“ERA rejects the recommendation contained in the study that black roofing be banned in warmer climates,” the organisation posted to comments on *The Fifth Estate*.

“Due to the complexity of roof and building science, prescriptive requirements that limit choices available to the architectural and building owner community are not in the best interest of good roof system design. Our overriding concern is that building owners and their design professionals are provided with science-based, field-tested information to help them make the choice of a roofing system that will meet their needs. Additionally, ERA feels that it is imperative to defer any decision related to roof design to architects and/or roof consultants, who have the proper training and understanding of all of the components found within a roofing system.”

It also noted concerns with the credibility of Berkeley’s scientific procedures, saying there were “extreme shortcomings”.

WHERE TO FOR AUSTRALIA?

Taking into account better financial performance through energy savings as well as the ability to tackle externalities such as the urban heat island, climate change and peak demand, in an Australian context of hotter summers and an increased frequency and duration of heatwaves it seems that the implementation of cool roofs could be a responsible solution for much of Australia.

As commentators have noted, this is climate-dependent, and in heating-dominant contexts a cool roof may not be ideal. And while increased levels of sarking and insulation can offset the increased heat load of a black roof, this is an extra cost to builders and does nothing to address the significant externalities.

With consumer demand for black roofs showing no sign of stopping in the residential context, and the externalities becoming more pronounced thanks to climate change, is it time for governments to step in and consider cool roof requirements in the residential context?

Comments

7 Responses to “Cool roofs versus dark roofs: special report”

Peggy Bailey says:

22 November 2014 at 2:45 pm

“ Hello!

I am about to build a 13 sq home .Due to low income my house will start its life with no heating or cooling.

It will have Dark clay bricks.Colour Bond Surfmist roof, White windows although the use of eaves is suppose to be better i have removed these to gain a credit towards extra celing height. This will be 2550 this gives me space to put in my favourtie cooling ceiling fans.

I live in Albury Wodonga so we get cold in winter and have high temps in summer up to 45

The insulation in walls is a rating of 2 and roof 4.

My house faces north with having two outside walls not having windows and putting a verhanda out fromt and back didnt see the need for Eaves. It will be interesting to see how my little home works in its first year.

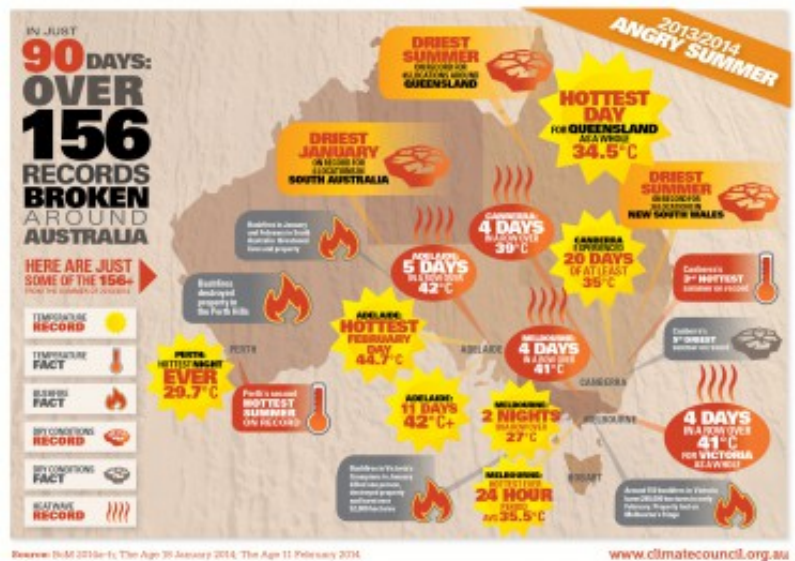
Nick says:

19 March 2014 at 3:42 pm

“ Seems like a lot of fuss for this trendy idea that will have very little impact on energy consumption for most new buildings with insulation, whereas we could be raising more worthwhile concerns (say accuracy of rating tools or their implementation, condensation risks of foil, why not even mandating PV if we’re talking about mandates!).

All the reports regarding light roofs particularly for Sydney & Melbourne have shown very negligible impacts on energy use, given that they generally mean slightly higher winter energy use despite slightly lower summer energy use. As most of the reports including the Melbourne report quoted in the article state, with sufficient insulation (i.e. all new buildings with these dark roofs) the effect of external solar absorptance is pretty minor.

You've also missed that the BCA/NCC already accounts for solar absorptance by requiring higher insulation in Climate Zones 1, 2 & 3 for



The angry summer: heatwaves and hot days dominated the last Australian summer.

darker roofs.

TFEJournos says:

19 March 2014 at 5:09 pm

☛ Thanks for the feedback Nick. Sure insulation can overcome the problem of high solar absorptance of black roofs but as Dr Reardon said, why create a problem in the first place?

☐ Besides, the main point trying to be made was that there are externalities to do with more than just individual building performance, namely the urban heat island effect, which the PNAS report quoted showed could be successfully battled through the widespread use of roofs with low solar absorptance.

☐ So even if there's only marginal improvements in individual energy use through cool roofs, I don't think attempting to tackle the negative externalities of urban development through white roofs is just a "trendy idea" or not a worthwhile concern to have, especially in the context of increasing temperatures and heatwaves.

☐— Cameron

Dick Clarke says:

14 March 2014 at 4:34 pm

“ Nicely put Steve. But all other things being equal (ie status quo for construction systems) colour is indeed a key factor. The RTAA's own research out of Newcastle Uni shows this without doubt, contrary to what their website is quoted as saying in this excellent article.

Ray Rose says:

14 March 2014 at 4:13 pm

“ A great article, covering both sides of the equation, but it needs expanding to address the issue of the "existing" residential housing stock (colours and types) with some recommendations as to application of heat-reflective paint to those existing dwellings

A solution only aimed at "new" housing is one-sided and insufficient to overcome market preferences (buyers or councils) regarding colour selection criteria and current trends, heritage considerations, etc

That study into existing dwellings would be the next step Dr. Chris Reardon could undertake. Not many owners would pay the cost to strip off and re-install perfectly good existing roofing tiles or sheeting to back-fit insulation. Payback period in power savings (assuming there are some) would be uneconomic. No advantage to increased house resale prices either.

Emma Thirkell says:

14 March 2014 at 8:00 am

“ The Tropical Green Building Network based in Cairns advocates for buildings with light coloured roofs in tropical Northern Australia.

Unfortunately house designs that suit temperate and cold climates proliferate in our newer suburbs. Project home builders deliver ‘cookie cutter’ designs that could just as easily suit a Melbourne suburb. New residents to the tropics may feel this type of house is normal. But what is not normal is the costly amount of insulation the house will need to combat heat absorption, the high amount of energy the house will consume to run air-conditioning to keep it comfortable and worst of all, the potential for condensation causing mould and rot in a hot humid climate.

In tropical Australia, zinc alum and steel sheeting was normally used until the 1980’s. The advent of black roofs is recent. Over the last 30 years some of this housing type has aged and they are ‘poverty traps’. Many are rented and families and pensioners occupy them because the rent is cheap. In summer they turn into ‘hot boxes’ and recently with the rising costs of electricity these people simply cannot afford to turn on air-conditioning.

Badly designed houses with black roofs are supposedly presented this way to attract people moving to Northern Australia who are unaware of how poorly they perform over time. We believe it is time that planning and building codes that are in place to protect people by setting down minimum standards introduce or modify codes that stipulate light coloured roofs for tropical Australia.

Steve King says:

13 March 2014 at 10:22 pm

“ The best thing about this article is that it draws together in one place most of the conflicting considerations in choice of roof colour, and even to some extent, roof material. The worst thing is that it is missing perhaps the most important variable: the construction of the roof.

The issue with roof colour is the absorption of solar radiation. In any climate where summer overheating is an issue, the solar radiation absorbed rather than reflected has the same effect as raising the outside temperature, and therefore the temperature difference between outside and inside with which any insulation under the roof then has to deal.

But this is only true if the roof is mainly relying on reducing the heat flow by conduction. It becomes less important if the roof system has low emissivity cavities which are effectively ventilated to the outside. In an ideal version of such a roof, the ‘inside’ face of the cavity would be barely warmer than the temperature of the ventilating air, and therefore the effect of the solar radiation would be effectively neutralised,

regardless of the roof colour.

In some other countries, such ventilated roofs are commonplace, even usual. It is important to understand that we are not talking about a ventilated attic. Rather, the ventilated cavity is directly under the roofing material, with the low emissivity achieved by the first of Chris Reardon's 'double sarking' materials, being a downward facing foil faced membrane. The cavity is then formed by a rigid sheet lining, supporting the second of the 'double sarking' layers, this time with upward facing foil. The secret to the arrangement is to leave an unobstructed air path that will turn into an efficient buoyancy driven air stream, inducing intake at the low point and exhausting hot air at the ridge. This is achieved by the primary battens running up the slope of the roof, rather than across the slope.

Anyone who has followed the description so far will realise that the system ironically works best if the roof sheeting is dark, because that will provide the necessary heat to drive the ventilation.

So what about winter, when it would be good to benefit from the extra heat absorbed by the dark roof? An additional elaboration of the system switches over to capturing the warm air in the cavity, and pulls it into the house interior. Admittedly, this may require a fan, but the fan power is small compared to the heating obtained.

In case anyone thinks the description is fanciful. it is in fact essentially the type of roof construction employed in Japan, parts of Europe, and in North America. Only the last bit, the winter heat capture is a relatively recent development, as exemplified by the Japanese OM system, which gathers so much heat from a typically small Japanese house roof, that it also puts a heat exchanger in the loop to provide the prodigious amounts of hot water needed to support traditional Japanese bathing habits.

So why don't we build such roofs in Oz? Because we traditionally used to think it's for those wankers overseas, while we can save heaps doing away with the plywood sheeting, and even sarking under the tiles. Well, the time has come to look again at what those wankers are doing, why they are doing it, and to spend a little more on building energy efficient smaller houses, rather than the world's biggest poorly built homes.

Oh yes. And then you can have your black roof and feel good about it.

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