Home ventilation systems

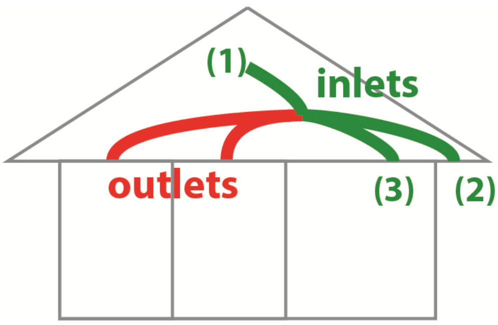
This guide was written by Sustainable Living Tasmania's Executive Officer, Todd Houstein - a qualified engineer and self-confessed "energy nerd". He conducted a desktop study, met with the three major suppliers in Tasmania, and surveyed 121 Tasmanian households with existing systems.

Home ventilation systems are intended to do one or more of the following:

- **Condensation control:** Reduce humidity and associated condensation problems by introducing dry air into the home and forcing moist air out.
- **Roof heat recovery:** Recover warmth from the roof cavity and distributing it into the home.
- **Heat transfer:** Transfer warmth from the primary heater to other parts of the home.
- **Summer cooling:** Expel warmth from the home and/or roof cavity to outside. Summer cooling is not covered in any detail in this guide due to low / infrequent need in Tasmania.

Only the systems most popular in Tasmania are covered in this guide. Systems with different approaches are available and may be worth considering. In particular, 'balanced pressure with heat recovery' systems should be considered for highly efficient, tightly sealed new builds; but are not covered in this guide.

Figure 1 Systems may have inlets from (1) roof cavity, (2) outside, or (3) the living room. They may have any number of outlets throughout the home.



Systems with inlets from the roof cavity or outside are also known as "positive pressure" systems, as they draw in air from outside the home, which forces air out of other places (generally the same gaps that allow draughts in a home such as around door and window frames, through ceiling fans and vents, and between walls and floors, or walls and ceilings.

Systems that only have an inlet in the living room are also known as "balanced pressure" systems, as they simply move air from one part of the home to another.

In summary, our conclusions and recommendations are:

- Most survey respondents were highly satisfied (54%) or satisfied (33%) with their ventilation systems (see page 13).
- Systems with a roof cavity inlet and/or outside inlet are highly effective at reducing condensation problems (see page 12), although we recommend trying other options first (see page 3).
- Systems are less reliable at improving comfort and energy use (see page 13).

- There is doubt around how much useful warmth a roof heat recovery system can provide. It is highest in autumn and spring, and for homes with poor passive solar gain (see page 5). Building materials and construction are other likely factors not explored in this report.
- In general we recommend only heating the room(s) you are using, a practice which most currently available heat transfer systems prevent. As such, we recommend against heat transfer systems except under particular circumstances (see page 6).
- All currently available systems have suboptimal controllers. We specify optimal control logic as a challenge for suppliers to implement to improve their products (see page 10).

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System types

Condensation control

What's the problem?

Condensation on windows, walls, and curtains is a common problem in Tasmanian homes. It occurs when air inside the home is moist and cold.

Moisture is introduced into the air in homes by showering, bathing, drying clothes, cooking, and people breathing.

When the temperature drops, this moisture can condense onto surfaces, causing stains, rot, mould and mildew. Mould and mildew can cause problems with respiratory health.

First steps to solving it

First minimise moisture being introduced to the air in your home:

- **Shower / bath**: Close the bathroom door, slightly open a window, and run the extractor fan (during or immediately after showering/bathing). This will allow the moist air to be replaced with fresh air from outside.
- **Drying clothes:** Wherever possible, avoid drying clothes inside – especially in rooms that that experience condensation problems. Drying clothes outdoors is best; a sheltered veranda is ideal when during rain. If using an electric dryer, install ducting to vent moist air out side. If you can't install ducting, then close the laundry door and open a window.
- **Cooking:** Cook with lids on pots whenever possible. Turn on extractor fan and slightly open an external window while cooking.
- **Breathing:** Let fresh air through the home on a regular basis by opening doors and windows, preferably during the warmest part of the day. Choose which windows/doors to open strategically to maximise fresh air flow, particularly in rooms that suffer condensation problems.

If you still have problems with condensation, the next step is to ensure you have adequate insulation, especially in the ceiling, but also underfloor and walls if possible. Adding insulation may reduce or eliminate condensation problems by keeping your home warmer (so that the room temperature doesn't get down to the dew point, or at least not as often). Insulation has the additional benefits of making your home more comfortable and cheaper to heat.

If you still experience condensation problems then a condensation control ventilation system is the next logical step, and is likely to eliminate or significantly reduce them – 92% of respondents to our survey of households with ventilation systems (page 10) reported condensation problems being eliminated or significantly reduced after installing condensation control ventilation systems.

Condensation control ventilation systems

Condensation control systems replace air in the home with air from outside where it is generally drier (although often also colder). Air is usually drawn in from an inlet in the roof cavity or directly from outside.

Roof cavity inlets

Some claim roof cavities are generally warmer than outside, which may help to heat the home, or at least not cool it as much as introducing air directly from outside. However there is significant doubt about this claim.

Note that condensation control systems continue to pump air from the roof cavity into the home throughout the night when it is cold. A Melbourne case study[1] found that on 75% of nights the roof cavity was colder than outside[2]. Being just a single case study, it is unreasonable to conclude this is the case for all homes, however it does prove that roof cavities are not necessarily warmer than outside (See also Roof Heat Recovery on page 5).

There are some important considerations for roof cavity inlets:

1. There must be sufficient air leakage between the roof cavity and outside to allow fresh air to be drawn in. This is not a problem with practically all old buildings, but may occasionally be a problem in new buildings since more attention is paid to sealing up gaps for energy efficiency purposes.

2. There must be minimal air leakage between the roof cavity and the home; otherwise the ventilation system will cycle moist air between the home and the roof cavity, rather than introducing fresh air from outside. Gaps are often found around recessed light fittings, or between ceilings and walls.

3. Bathroom and kitchen exhaust fans that blow into the ceiling space can also be problematic for roof cavity inlets, as the moisture that the fans exhaust can simply be reintroduced to the home if sucked in by a roof cavity inlet. All ceiling fans should be ducted out of the home before installing a condensation control system with a roof cavity inlet.

4. Roof cavities are dusty places, and so a filter must be fitted to the inlet. This is standard with any professional system, although some suppliers use higher quality filters than others. People with asthma or allergies should have a filter that sufficiently filters their particular trigger(s). Filters require regular maintenance and occasional replacement. Ensure you're aware of these requirements and associated costs before investing in a system.

Condensation in the roof cavity

Some homes experience condensation problems in the roof cavity. This can degrade ceiling insulation, rot timber, and cause mould and mildew.

Ceiling fans that vent directly into the roof cavity are the main culprit for introducing moisture into roof cavities. Fans should be ducted to outside the home, usually through an eave.

If roof cavity condensation problems persist then seek expert advice.

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[1] While we could not find this case study online, it was covered in McChesney, Ian; Home Ventilation Systems Assessment, Report to the Energy Efficiency and Conservation Authority (EECA); January 2009. The case study was referenced in the report as "Elliot, Stuart. 2008. Glen Iris Case Study – A Performance Report on the HRV System. – report provided to the author by HRV Ltd, New Zealand".

[2] McChesney (2009) explained "This is not surprising and is consistent with 1st principles based on longwave radiation losses back into the night sky, and wind convection/rain conduction losses.

Outside inlets

Because they draw air directly from outside, systems with these inlets don't have the same requirements about air leakage between the home and roof cavity (although you should draught-proof anyway to keep warmth in) or roof cavity and outside.

There are a couple of important considerations for outside inlets:

1. Even though they bring in fresh air, outside inlets may also bring in smoke, pollen and dust. Minimise pollen and dust by installing the inlet in a position that is sheltered from predominant winds. Also consider the location of any nearby chimneys to avoid or minimise smoke intake.

2. At least a basic filter should be fitted on outside inlets, and a higher performance filter should be considered. People with asthma or allergies should have a filter that sufficiently filters their particular trigger(s). Filters require regular maintenance and occasional replacement. Ensure you're aware of these requirements and associated costs before investing in a system.

Roof heat recovery

Roof cavities are warmed by the sun, and also by heat escaping from the home up through the ceiling. Roof heat recovery systems attempt to duct this heat into the home from an inlet in the roof cavity.

The potential heat available varies widely depending on weather (sun, cloud cover, and rain) and the design, materials & construction of the home and the roof.

If you have good 'passive solar gain' (i.e. north-facing windows that let in the winter sun), then you're already getting plenty of warmth when it is sunny and are unlikely to experience much benefit from a roof heat recovery system.

If you have poor passive solar gain and are unable to rectify this (e.g. through renovations), then a roof heat recovery system may be beneficial.

A frequent comment from our survey of households with ventilation systems (page 10), was that roof heat recovery was effective in the shoulder seasons (autumn and spring), but not so much in winter.

A study conducted in New Zealand, where ventilation systems are more prevalent and the climate is similar, concluded:

> *"It was found that small potential heating and cooling benefits were possible at certain times from pumping air from the roof space into the living areas of some New Zealand houses. However those potential benefits were not large enough to significantly alter the indoor air temperature on average.*
>
> *In 2008, ten-day periods in January, April, June and September were modelled to represent each of the four seasons. The maximum cooling potential of pumping cool air down from the roof cavity was around 1 kW. The maximum heating potential was only 0.52 kW, which is approximately equivalent to the heat output from five 100 watt light bulbs.*

The majority of the time, it was calculated that pumping air from the roof space into the house would provide no heating or cooling benefit. In fact, this would often actually act to push the internal temperature further away from the desired level rather than closer to it.

Based on the modelling work detailed in this report, it is therefore recommended that ***existing positive pressure mechanical ventilation systems should not be promoted and marketed on their heating and/or cooling potential.****"*

This finding is corroborated by a UK study:

The early study in the UK by Stephen found that the roof space provided an overall temperature gain of about 3°C compared with outside air over a period of several months in the winter. Energy performance overall was difficult to establish but it was concluded that the relative saving in an average modern family house was a maximum of about 150 Watts continuous (equivalent to about 550kWh over a heating season, or 10% of annual space heating cost) (note that this assumes that the problem they encountered with recirculation of room air via the roof space will be minimised).

The saving was relative to a conventional extract system providing the same level of ventilation air exchange. Once account was taken of fan motor use ***they concluded there was little overall net energy saving.***

Regarding heat that escapes the home up through the ceiling, the best approach is to keep it in the home longer with draught-proofing and ceiling insulation, rather than trying to pump it back into the home after it is lost.

Heat transfer

Ventilation systems can be designed to circulate existing air around the house by drawing air from one room (usually the living room) and blowing it into others. The air returns to the first room via the easiest path(s) and mixes together along the way. The intent is to spread warmth from a primary heater or sunny room throughout the home.

In effect, the system is more or less averaging out the temperature across all rooms with vents plus any connecting halls/rooms.

In all but exceptional circumstances, this will use more energy than only heating the room(s) you are using at the time, which is Sustainable Living Tasmania's advised strategy.

Systems on the market today do not allow you to turn on or off the outlets in each room separately (at least not easily). The best you can do is close the door to reduce air and heat flow to/from that room. As such, it is important to consider which rooms you actually want to keep warm. Installing an outlet in a cold room that you rarely use will increase your energy consumption for little gain in comfort.

Transferring warmth from the primary heater

Heat transfer systems are of most benefit to homes that:

1. have an efficient primary heater that is over-sized (i.e. capable of heating a significantly larger area than the room it is in);

   AND
2. are currently spending a lot of money running inefficient heaters (e.g. any electrical heater other than a heat pump) to heat other rooms in the home.

In those conditions, the efficient primary heater can be used to heat other rooms, allowing other inefficient heaters to be switched off.

Generally only wood or pellet heaters are suitable. Heat pumps can also be suitable, but they rarely have enough excess capacity as they are usually sized specifically for the room they are in. All other heater types are inefficient and expensive to run and we recommend against them at all, let alone in conjunction with heat transfer systems.

If you do not currently heat the other rooms often/much, then by installing a heat transfer system you will have warmer rooms but higher energy bills.

Transferring warmth from a sunny room

Heat transfer systems can also benefit homes that:

1. have a room that is well heated by the winter sun during the day.

   AND
2. are currently spending a lot of money heating other rooms during the day.

In those conditions, warmth can be transferred from the sunny room to other rooms.

If you do not currently heat the other rooms during the day then you will have warmer rooms during the day, but no change to your energy bills.

Benefits can continue after it stops being sunny, but only if the home has high internal thermal mass (internal walls or floors made from brick, concrete, or similar material that stores heat well) and good insulation, in which case your home is likely already energy efficient and won't benefit as much from a heat transfer system.

Controllers

Different makes and models are controlled in different ways. The control depends largely on the combination of inlets (roof cavity and/or outside and/or living room). Below we explain the controllers of the most popular system types in Tasmania.

We describe only the main logic behind how the systems are automatically controlled. All systems can be manually controlled to greater or lesser extents, and some have additional functionality that is not described below (e.g. summer cooling mode, minimum and maximum temperature set points below/above which the systems switch off altogether so as to not overheat or overcool your home, etc).

All currently available systems have suboptimal controllers. Below, we specify optimal control logic as a challenge for suppliers to implement to improve their products (see page 10).

HEG (Home Efficiency Group)

All HEG systems have living room inlets; the vast majority also have roof cavity inlets, and some have room, roof, and outside inlets. Below we describe the control logic for systems with multiple inlets.

Their system is controlled based on roof cavity temperature alone, with a roof cavity temperature set point that is user programmable, but designed to be 'set and forget'.

The system is designed to transfer air from the living room constantly, with air from the roof cavity mixed in when it is warmer:

- When the roof cavity temperature is below the set point, air is drawn 100% from the living room. The intent is to evenly distribute warmth throughout the home. As discussed above, we generally disagree with this approach as it heats rooms even when you are not using them, resulting in higher energy use than need be.
- When the roof cavity is above the set point temperature, air is drawn approximately 50% from the roof cavity and 50% from the living room. The intent is to heat the home with warm and dry air from the roof cavity, which makes sense. The intent behind also drawing air from the living room is to ensure it is evenly distributed throughout the home including the living room, which also makes sense.

  There is a potential problem with this controller, but it is easily overcome with user intervention. To illustrate, imagine someone comes to visit who really feels the cold, so you turn up the heater up for them. The heater is now trying to heat the room to 25°C, but the ventilation system is pumping 22°C air in from the roof cavity. Effectively, the ventilation system is fighting against the heater – wasting energy and money. This can be solved by temporarily increasing the set point to a higher temperature, or switching the system off altogether.

For homes with the most severe condensation problems, HEG generally recommend an additional inlet from outside. Their system continually draws a small amount of air (a few percent according to the supplier), regardless of temperature or humidity. This system may be more effective at tackling condensation, but may be often introducing cold air into the home unnecessarily.

Tas Vent

The majority of Tas Vent's systems have inlets from the roof cavity and living room (some also have an outdoor inlet for summer cooling, but the control of these systems is not covered here).

Their system is controlled based on roof cavity temperature and living room temperature, with a living room temperature set point that is user programmable, but designed to be 'set and forget'.

- Air is drawn from the living room when it is warmer than the roof cavity *and* above the set point temperature (e.g. at night when the heater). The intent is to distribute warmth from the heater in the living room to other areas of the home. As discussed above, we generally disagree with this approach as it heats rooms even when you are not using them, resulting in higher energy use than need be.
- Air is drawn from the roof cavity when it is warmer than the living room (e.g. on sunny days). The intent is to heat the home with warm and dry air from the roof cavity, which makes sense. However, the warm

and dry air is not directed into the living room because the vent in that room is blocked off in this mode. Some warmth may still make it into the living room indirectly from other parts of the home.

- Air is also drawn from the roof cavity when it is colder than the living room, and the living room is below the temperature set point (most common at night and when the heater is off). In this case the fan speed is reduced to a minimum. The intent is to continue to introduce dry air for condensation control reasons. As discussed above, this may often be unnecessary and counterproductive as it makes the house colder.

Pellet Fires Tas

Pellet Fires Tas' systems generally have a single inlet in the roof cavity.

Their system is controlled based on roof cavity temperature alone, with a roof cavity temperature set point that is user programmable:

- When the roof cavity temperature is above the set point the fan speed is high. The intent is to heat the home with warm and dry air from the roof cavity, which makes sense.

  As with HEG, there is a potential problem with this controller, but it is easily overcome with user intervention. To illustrate, imagine someone comes to visit who really feels the cold, so you turn up the heater up for them. The heater is now trying to heat the room to 25°C, but the ventilation system is pumping 22°C air in from the roof cavity. Effectively, the ventilation system is fighting against the heater – wasting energy and money. This can be solved by temporarily increasing the set point to a higher temperature, or switching the ventilation system off altogether.
- When the roof cavity is below the set point, the fan speed is reduced to a minimum. The intent is to continue to introduce dry air for condensation control reasons. As discussed above, this may often be unnecessary and counterproductive as it makes the house colder.

Unnecessary cooling

The results from our survey suggest that condensation problems in many households can be solved by introducing dry air only when it is relatively warm outside… HEG systems with living room and roof cavity inlets only introduce new air to the home when the roof cavity is warm; otherwise they cycle existing air within the home. 5 out of 5 survey respondents with this system reported severe condensation problems (e.g. "every day wet windows and mould") being completely eliminated, or all but completely eliminated, after installing the system (e.g. "at most, once a winter if very cold night"). This proves condensation control systems do not necessarily need to introduce dry air when it is very cold.

However, most systems continue to pump air in from the roof cavity or outside, even when it is cold. This may often be unnecessary and counterproductive by making the house colder.

The extent of this problem has not been researched to our knowledge. Suppliers claim the cooling is negligible because fan speed is reduced to a minimum in these conditions, however 4 survey respondents complained specifically about cold air being blown into their house at times.

Regardless of the extent of this problem, it could be easily solved (see How Controllers Should Work).

How controllers should work

Given that their primary function is to manage indoor humidity, systems should factor this into the control. We find it astonishing that no product currently on the market does so.

This means that systems pump cold from the roof cavity (or outside) into the home even when it is unnecessary because the indoor air is already dry enough, and counterproductive because the roof cavity (or outside) air is cold. The frequency and extent of this problem would vary from home to home, and it has not been studied to our knowledge, but we do know that 4 survey respondents complained about cold air being pumped into their home at times.

Sustainable Living Tasmania would like to see a controller that factors in humidity, only bringing in air from the roof cavity when:

- Inside is above a set humidity and the roof cavity is less humid (drying mode);
  OR
- Inside is below a set temperature and roof cavity is warmer (heating mode).
  OR
- Inside is above a set temperature and roof cavity is cooler (cooling mode).

Bringing in air from the roof cavity under any other conditions is unnecessary and counterproductive.

The same logic applies to an outdoor inlet.

Aside from a one-off development cost, this control logic would not be expensive to implement. Electronic components that sense both temperature and humidity cost about $10 (less in bulk), which is only a fraction of a percent of the typical cost of a home ventilation system.

Survey of households with ventilation systems

Sustainable Living Tasmania devised a survey of households with ventilation systems. It asked about the system installed, and the conditions before and after installation.

The survey was promoted publicly on social media and specifically to past customers of the three largest suppliers in Tasmania: Pellet Fires Tas, Tas Vent, and HEG (Home Efficiency Group).

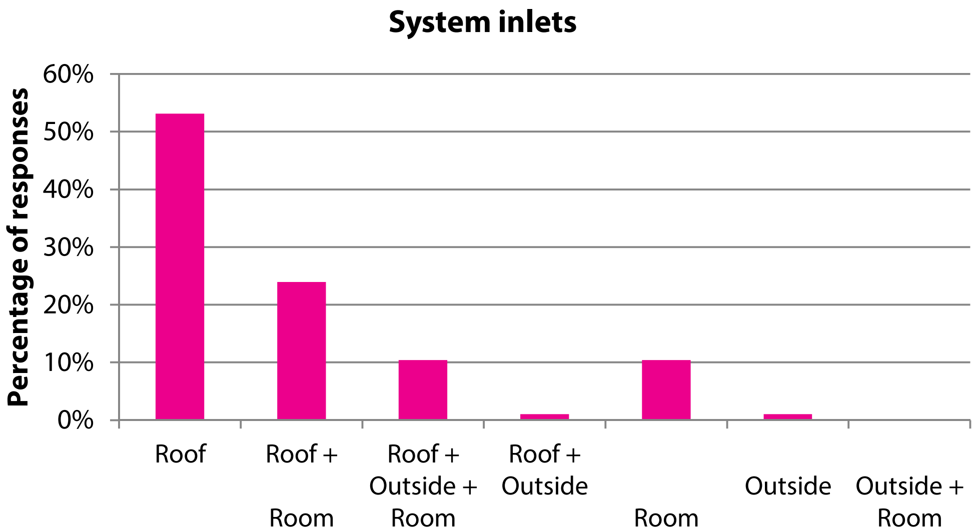
121 people responded to the survey. The results are graphed and discussed below.

System types

Most respondents (90%) had an inlet from the roof cavity, with some of those having additional inlets from a room and/or outside. This reflects that most people are installing systems to tackle condensation problems.

9% had an inlet from a room only – that is, their systems were intended for heat transfer only.

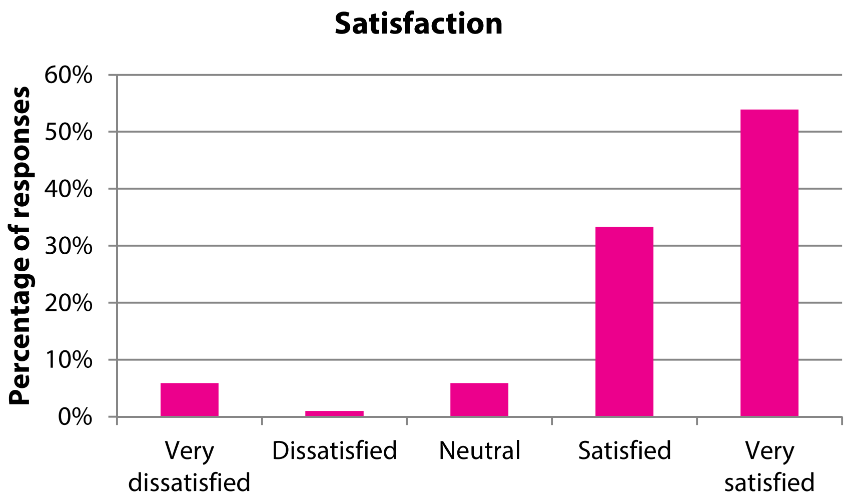
1% (just 1 respondent) had an inlet from the outside only.



Satisfaction

Respondents were asked" Overall, how satisfied are you with your ventilation / condensation control system?". Respondents that reported also having made other improvements (e.g. insulation, new heater, etc.) at the time of installing their ventilation system were excluded so as to not skew results. The responses are graphed below.

When translated to a 1-5 score, the average score is 4.23. There was little difference in average satisfaction between suppliers or system types.



Complaints

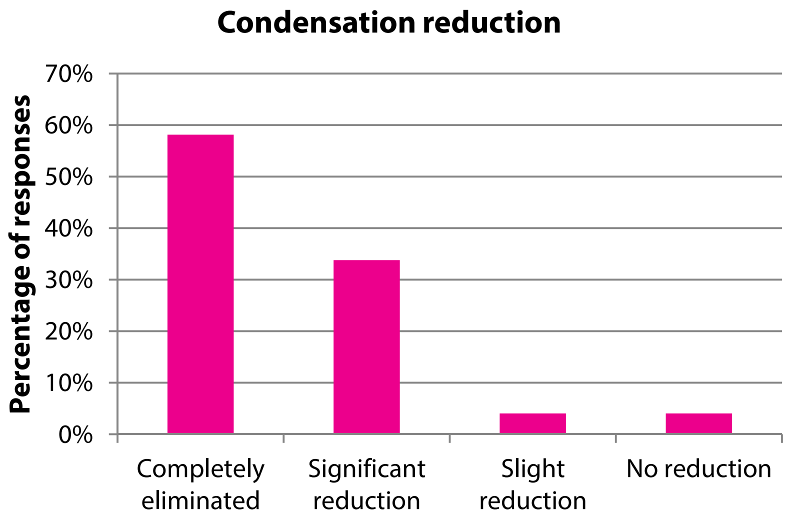
Complaint	Number of respondents	Our comments
Poor customer service	5	1 or 2 respondents for each of the main suppliers in Tasmania
Cold air blown into the home at times	4	
Hot air blown into the home in summer	4	Some systems handle this automatically, others need to be manually switched off in summer – the trick is remembering to do so.
Performance didn't meet expectations	4	
Lack of advice or documentation on how to operate the system	3	
Running cost	1	
Sometimes dust is blown into the home	1	This suggests a faulty filter or leak somewhere in the system that should be able to be rectified.
Noise – vents rattle when it is windy	1	

Condensation

88% of respondents said they had condensation problems before installing the system. Below are some of the respondents' descriptions that typify the severity of the problems they had experienced:

- *Condensation, every day in winter. Large puddles.*
- *Wet windows, wet curtains. Water running down them.*
- *We had crying windows every morning in winter, this was causing mould to appear along our window frames, in our cupboards and rotting our timber window ledges.*
- *In winter windows were so bad i used up to 4 towels each day depending on how low outside temperature was*
- *Frequent weeping windows which resulted in serious mould / mildew infestations to ceilings, walls & window surrounds.*

The majority (92%) reported condensation problems being completely or significantly reduced. This result excludes respondents that reported having made other improvements (e.g. insulation, new heater, etc) at the time of installing their ventilation system.



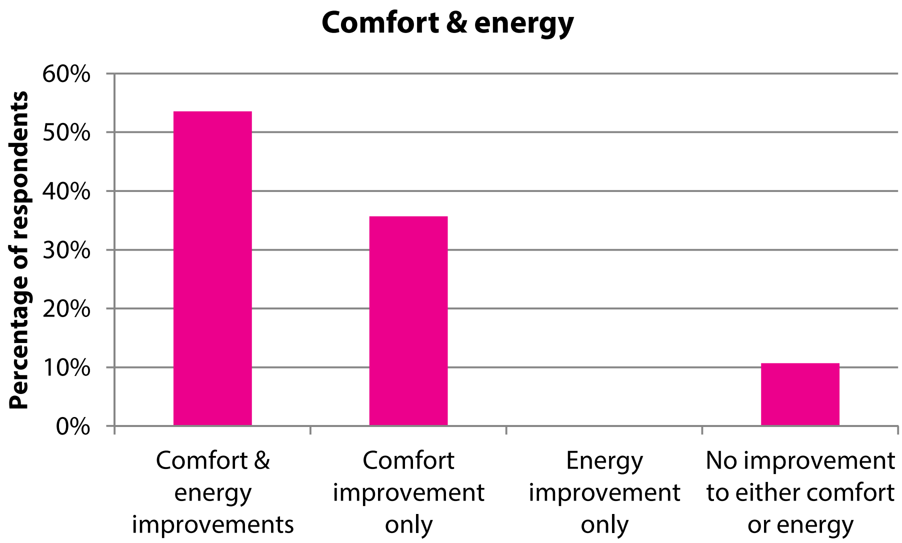
Comfort and energy

Respondents were asked about changes in comfort (e.g. warmth) and energy use. There are several challenges in interpreting the results:

1. **Efficiency involves both warmth and energy use:** A home can be made warmer by spending more money on heating, or money can be saved by not running heaters. As such, warmth and energy use need to be considered simultaneously to evaluate whether a change has made a home more or less efficient.
2. **Other influences:** Warmth and energy use can change dramatically over time due to other factors including weather, occupancy, electricity prices, and behaviour.
3. **Confirmation bias**: People like to think they've made a wise choice, and have a tendency to notice positives and ignore negatives.
4. **Flawed survey design:** We didn't allow people to identify reductions in comfort or increases in energy use. We later asked respondents to clarify, but only a small number responded.

Considering these challenges, it is difficult to draw confident conclusions from the responses to these questions.

Respondents that reported also having made other improvements (e.g. insulation, new heater, etc) at the time of installing their ventilation system were filtered out so as to not skew results.



The results, graphed above, suggest that outcomes vary widely from home to home. The most significant variable was the passive solar gain of the home. 20% of those with high passive solar gain reported no improvement in either comfort or energy use, compared to only 7% of those with low passive solar gain[3]. This supports our conclusion that roof heat recovery systems are more useful for homes with low passive solar gain.

There was insufficient data to pick up relationships between outcomes and any other variables, including supplier and system type.

Major suppliers in Tasmania

(Listed alphabetically)

DMS Energy
tasmaniansolar.com.au
1300 502 599

Pellet Fires Tas
pftas.com.au
6273 7644

HEG (Home Efficiency Group)
homeefficiencygroup.com.au
1300 96 80 60

Tas Vent
tasvent.com.au
6339 4300

[3] Amount of solar gain was determined by asking "Before you had the system installed… Which of the following statements best describes what your home was like on COLD BUT SUNNY winter days? (1) The sun warmed up the house nicely, so I didn't need to switch the heater on until the evening, (2) I got a bit of warmth from the sun, but still needed to use my heater quite a bit on cold sunny days, or (3) On cold days I needed to use a heater regardless of how sunny it was." Responses 1, 2 and 3 were categorised as high, medium and low passive solar gain respectively.